SOME EFFECTS OF INCREASED TEMPERATURE ON THE SETTLEMENT AND DEVELOPMENT OF A MARINE COMMUNITY IN THE LABORATORY

by

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ABSTRACT

The torrents of heated seawater discharged from coastal power plants alter a host of environmental parameters. In addition to elevating the temperature of the receiving water, power plant outfalls create turbulent, turbid conditions and introduce toxic chemicals, such as chlorine, into the marine environment. It is usually assumed that the thermal addition will have by far the greatest effect on marine organisms. Yet, it has rarely been possible in the field to distinguish the effect of increased temperature from the influence of power plant-induced changes in other physical and chemical parameters. This research was designed to isolate the effect of elevated temperature from other factors associated with the operation of a power plant outfall by simulating, in the laboratory, temperature regimes characteristic of the thermal field around a coastal outfall.

Unfiltered seawater, drawn from the end of the Scripps Institution of Oceanography pier, was continually passed through four experimental aquaria. Two of these were unheated and served as the experimental control. The remaining two aquaria were heated with immersion heaters. The temperature of one of the heated tanks was continually maintained at 3°C above ambient to represent the condition in the immediate vicinity of a power plant outfall. The three-degree temperature elevation was chosen in order to focus on sublethal

effects. The thermal regime in the other heated tank consisted of six-hour intervals at 3°C above ambient alternating with six-hour intervals at ambient temperature. Intermittent heating is characteristic of the larger area around a coastal power plant outfall which is alternately exposed to heated water and ambient temperature water with each tidal rotation of the thermal effluent.

Sets of asbestos settling plates were suspended in the aquaria for periods of one month to a year, beginning March 1971. A diverse assemblage of epifaunal invertebrates, including sponges, coelenterates, ectoprocts, entoprocts, mollusks, annelids, arthropods, echinoderms and ascidians settled in the tanks. Information on abundance, size and reproduction was gathered for species on the settling plates, and two measures of species diversity, the number of species and the Shannon-Wiener index, were calculated for the communities. Nonparametric analyses of variance were performed on these population and community data in order to identify significant differences among the three regimes (ambient temperature, intermittently increased temperature, and continually increased temperature).

The response of individual species to increased temperature varied widely, ranging from enhancement to restriction of recruitment and growth in heated water compared to ambient temperature water. Reproduction began earlier in heated water for several species. The survival of a number of species was substantially reduced in continually heated water during the summer. In general, the settlement, growth, reproduction and survival of the species which settled on the plates were much less affected in intermittently heated water than in continually heated water.

The species diversity of the communities which developed in all three temperature regimes was comparable throughout the spring. By the end of summer, however, species diversity in both intermittently heated water and continually heated water was significantly lower than in ambient temperature water. During the fall, the diversity of the community in intermittently heated water returned to a level similar to that in ambient temperature water, but the diversity of the community in continually heated water had not recovered to the ambient level by the end of the succeeding winter when the experiment was terminated.

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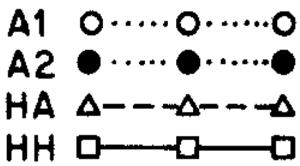
ABBREVIATIONS AND SYMBOLS USED IN FIGURES

Tank A1 = ambient temperature tank number 1

Tank A2 = ambient temperature tank number 2

Tank HA = intermittently heated tank

Tank HH = continually heated tank



t = time

S = set of plates

ABBREVIATIONS AND SYMBOLS USED IN TABLES

A1 = plate from ambient temperature tank number 1

A2 = plate from ambient temperature tank number 2

HA = plate from the intermittently heated tank

HH = plate from the continually heated tank

= number

Mn. = mean

Md. = median

Q = quadrat

Br. = branches

Zd. = zooids

The number of quadrats examined per plate in each set is given in parentheses.

Values associated with asterisks are significantly different at P = .05 [* *] or P = .01 [** **].

A blank space indicates no individuals observed on any plate in the set.

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INTRODUCTION

The voluminous literature concerning the effects of temperature on aquatic organisms indicates that temperature is probably the most important single environmental factor controlling marine life. Most studies of the effect of temperature on biological systems have had a physiological orientation or have dealt with the response of the whole organism. There is a dearth of information about the influence of temperature on aquatic populations or communities. Knowledge of temperature effects at these higher levels of biological organization is essential for an accurate assessment of the consequences of thermal elevation of the marine environment resulting from the discharge of heated seawater by coastal steam-electric generating stations.

I studied the effect of elevated temperature on the settlement and development of the near-shore Southern California marine fouling community (epifaunal invertebrates with meroplanktonic larvae) to generate the type of basic ecological information which could be of specific use in predicting the impact of thermal discharge on marine ecosystems. Before describing this research, I shall briefly review the literature dealing with temperature and aquatic life, then discuss why the electric power industry poses the greatest threat of marine thermal pollution.

Temperature and Aquatic Life

Innumerable studies have considered the influence of temperature on aquatic organisms. The literature has been compiled into bibliographies (Kennedy and Mihursky, 1967; Raney and Menzel, 1969) and extensively summarized (Brett, 1956; Gunter, 1957; Kinne, 1963, 1970; Wurtz and Renn, 1965; Coutant, 1968, 1969, 1970, 1971; Coutant and Goodyear, 1972; Jensen et al., 1969).

The results of practically all previous laboratory investigations of the thermal tolerance of freshwater and marine organisms are, however, of limited ecological value in predicting the effect of heated discharge from power plants, as short-term exposures and lethal temperatures have been emphasized. In addition, upper lethal temperatures for aquatic species have been commonly measured by raising the temperature of specimens in a water bath at a controlled rate until 50% or 100% mortality occurs (Kinne, 1963; Jensen et al., 1969). Temperature tolerance data obtained in this way can be misleading when applied to field situations. For example, by increasing temperature 1°C every five minutes, Henderson (1929) found 40.8°C to be the lethal temperature for _Mytilus edulis_, the common mussel. However, Wells and Gray (1960) found a much lower lethal temperature, 26.7°C, for _M. edulis_ in nature; they also demonstrated that the southern limit of this species in the Western Atlantic (Cape Hatteras) is set by its inability to survive higher summer temperatures south of that point.

Subjecting animals to a constant temperature, as is usual in the laboratory, is highly artificial, since temperature varies continuously in nature. Kinne (1963) has shown, for instance, that the brackish water amphipod, *Gammarus deubeni*, exhibits a normal growth rate, sex ratio and life span *only* under fluctuating temperature conditions which are similar to those experienced in the field. Furthermore, most laboratory research (with some notable exceptions, e.g., Patrick, 1967, 1968, 1971; McIntire, 1968) has dealt with single species isolated from the community in which they normally occur. But, the response of a species in the absence of its usual biological interactions may have little relevance to the natural situation.

Field studies, on the other hand, have suffered from the lack of adequate experimental controls. Organisms in the field react to their total environment, and it has proved difficult to isolate the effect of single factors such as temperature under natural conditions (Hedgpeth and Gonor, 1969).

In spite of these difficulties, generalizations have emerged from the extensive research on temperature and life. I will not attempt to comprehensively review the literature, since good reviews (previously cited) already exist, but I think it is appropriate to convey some idea of the wide range of biological factors affected by temperature.

Many of the physical and chemical properties of water to which aquatic organisms respond (e.g., density, viscosity, gas solubility and osmotic pressure) are directly dependent on temperature. Metabolism is an integrated complex of chemical reactions and, as such, is also regulated by temperature within the normal physiological range: a 10°C rise approximately doubles an organism's over-all metabolic rate (Prosser and Brown, 1962). Although this rule presumably holds for the whole organism and for rates of physical processes associated with its metabolism, it is becoming apparent that the activity of many enzyme systems is relatively independent of temperature over the range which a species tolerates (Somero, 1969; Somero and Hochachka, 1971).

The range of temperature an aquatic organism can endure is ultimately set by its genotype; within those limits individual phenotypic thermal tolerance depends on a variety of factors, including water quality, age, condition, reproductive state and previous thermal history. Most aquatic ectotherms can acclimate to gradual temperature increases up to a critical level, at which point thermal death, evidently due to failure of the central nervous system, results (Roots and Prosser, 1962; Somero, 1969).

Within a species' vital range, temperature also exerts a profound influence. In temperate seas, during winter, the growth of the majority of marine and brackish water invertebrates is usually retarded, and some species do not grow at all. Marine ectotherms generally grow more slowly, mature later, and reach a greater final size in the colder areas of their distribution (Gunter, 1957). This relationship between temperature and growth, maturation and maximum size has also been demonstrated in the laboratory (Kinne, 1963).

The reproductive processes of aquatic species are especially temperature-sensitive. Breeding is commonly restricted to a considerably narrower temperature range than growth or survival. For example, the American oyster, *Crassostrea virginica*, can feed and grow at both lower and higher temperatures than are necessary for spawning (Gunter, 1957). The breeding cycle of most temperate marine organisms follows natural annual temperature fluctuations. Many species begin reproductive activity when water temperature rises or falls to a specific level, or at a particular temperature change, usually at an annual minimum or maximum.

Temperature also strongly influences behavioral patterns. Aquatic organisms are often able to perceive and select between very narrow temperature differences. For instance, the dwarf herring, *Jenkinsia lamprotaenia*, has been observed to discriminate between 29.5°C and 30°C under natural conditions (Breder, 1951). The migration of many marine and estuarine species is cued by temperature (Kinne, 1963). Thermal shock can reduce the ability of an organism to escape from a more temperature-resistant predator. A case in point is the debilitation of scallops by a sudden temperature change which renders them incapable of performing their characteristic escape response (Dickie and Medcoff, 1963).

Temperature may interact with a number of important abiotic and biotic factors. Elevated temperature usually decreases an organism's tolerance to environmental stresses, such as low salinity (Kinne, 1964). Generally, a rise of 10°C at a constant concentration of toxicants reduces the survival time of an organism by fifty percent (Jensen et al., 1969).

Temperature and salinity are considered the most important abiotic factors influencing the geographical distribution of aquatic organisms (Kinne, 1963, 1964). Orton (1920) and Hutchins (1947) were among the first to suggest that seawater temperature may be the decisive factor, biotic or abiotic, controlling the distribution of marine life.

Finally, a change in temperature can act at the level of community organization by affecting symbiotic relationships or competition. This is especially evident in cases of competition between closely related forms in the temperate latitudes, where subpolar and subtropical species occur together. A classic example was reported by Southward and Crisp (1954). They found that an increase in sea surface temperature in the British Isles resulted in the northward spread of a low-latitude species of barnacle, *Chthamalus* *stellatus*, at the expense of a high-latitude species, *Balanus balanoides*; the opposite situation occurred during years of low seawater temperature.

Investigations of Power Plant Thermal Effects

The studies and investigations referred to in the preceding section did not involve temperature alterations analagous to those induced in the marine environment by the discharge of power plant thermal effluent. The following sections will consider investigations aimed specifically at determining the effects of cooling-water discharge from power plants on the settlement and development of epifaunal communities.

The motivation for the earliest studies of power plant thermal effects was not concern for the well-being of aquatic communities exposed to thermal effluent. Rather, the research of Richie (1927), White (1950) and Chadwick, Clark and Fox (1950) was directed toward establishing countermeasures to combat the growth of fouling organisms in the cooling water intake conduits of power plants. These workers observed that the discharge conduits (which carry heated cooling-water away from the power plant) were rarely clogged with marine organisms, and reasoned that heat could be used to control fouling. Programs for "heat-treating" intake conduits were designed to eliminate the most resistant member of the fouling community, usually mussels (Fox and Corcoran, 1957). Heat-treatment involves reversing the flow of cooling-water, recirculating it in the plant until a temperature of 35°C or greater is reached, and then discharging the hot water through the intake conduits for six to eight hours. This procedure, performed every three or four weeks, has effectively controlled fouling at most marine power plants for the past 20 years.

In the late 1950's, scientists and engineers began investigating the effects of discharged thermal waste on communities inhabiting natural environments. The earliest of these studies was conducted at generating stations using fresh water for cooling (Van Vliet, 1957; Wurtz and Dolan, 1960; Coutant, 1962). Adams (1968a) has reviewed the ecological investigations of thermal discharge into fresh water.

Markowski (1959, 1960, 1962) was the first to publish field studies of the effects of cooling-water discharged from estuarine and marine power stations. The research reported in 1960 was an investigation of the establishment of an epifaunal community in heated water. Markowski placed concrete slabs both in the intake water and adjacent to the outfall of a generating station in England. The slabs were examined at monthly intervals over a year. A number of species appeared on the outfall slabs a month or two earlier than on the intake slabs. There was no striking difference in the species composition of the fauna which settled in the two areas over the year, but algae were found only on the outfall slabs. Markowski concluded that "the results indicate the outfall area is more favorable than the intake". However, the work was strictly qualitative, and several other criticisms of it (detailed in Hedgpeth and Gonor, 1969) render Markowski's conclusion problematical.

A similar but more detailed study was made by Nauman and Cory (1969) in the Patuxent River Estuary of Chesapeake Bay. Settling panels were placed in the intake and discharge canals of the Chalk Point power plant for one-month periods from February through December 1967. The temperature in the discharge canal averaged 6°C above the intake canal. Some species both attached and declined earlier in the discharge canal than in the intake canal. A total of 17 species occurred on the plates from the discharge canal, while only 14 were found on the intake plates. Species diversity in terms of Margalef's index ($D = S - 1/\ln N$, where S = the number of species and N = the total number of individuals) was higher on the plates exposed to thermal effluent during every month except July and August, when the maximum water temperatures occurred. There were generally higher densities of each species on the discharge canal plates, and biomass (dry weight and ash-free dry weight) was consistently greater on plates suspended in the thermal effluent.

The settling and growth of epifauna in marine environments receiving thermal input from power plants has also been studied in New York and Florida. Nugent (1970) suspended fouling panels at a number of stations in ambient water and within the thermal field surrounding the outfall of the Turkey Point power plant on Biscayne Bay, Florida. A variety of invertebrates attached to the panels, but the analysis of settlement and growth was limited to the most abundant species, the ivory barnacle, Balanus eburneus. Settlement of this barnacle occurred earlier and was more intense in the spring in heated water than at control stations. During the summer, barnacle settlement was restricted in warmer water; no barnacles settled in July and August at the station closest to the outfall. Growth was more rapid in heated water during the winter; the reverse was true during the summer.

In a preliminary report of a continuing study at a Long Island, New York, power plant, J. Pearce and J. Young (Studies on the Effects of a Steam-Electric Generating Plant on the Marine Environment at Northport, New York, 1971) state that the diversity of settling organisms was greater throughout the winter and spring in the discharge canal than in the intake waters. The temperature difference between intake and discharge canals was 15°C. Diversity in the discharge canal declined with the onset of warm summer temperatures, whereas diversity reached its peak in the intake canal during the summer. Mytilus edulis settled abundantly in the intake canal, but was absent on fouling panels suspended in the discharge canal. Earlier observations at this power plant (Biological Effects of Thermal Pollution, Northport, New York, 1970) also indicated that mussels were restricted from settling in the discharge canal.

Markowski (1960), Nauman and Cory (1969) and Pearce and Young (Studies on the Effects of a Steam-Electric Generating

Plant on the Marine Environment at Northport, New York, 1971) relate the effects reported in their field studies to the routine records of intake and discharge temperatures taken within the power plant. Only Nugent (1970) presents temperature records taken at the actual sampling site.

Comparable field studies of the development of epibenthic communities in the wake of thermal effluent from west coast power plants have not been made, although a number of ecological surveys have been carried out or are currently being performed at California power stations (Adams, 1968b, 1969a, b; Adams, Gormly and Doyle, 1971; Ford, 1968; Ford and Clark, 1970; Duffy, 1970; Edison Electric Institute, 1971).

A variety of tropical or subtropical species not native to Britain have become established in heated docks or in thermally elevated environments adjacent to power plant outfalls in England (Naylor, 1965b). Most of these species were probably carried to Britain by ships, either in seawater ballast tanks or attached to the hulls. Shipping lanes do not pass near offshore power plant outfalls on the United States west coast, so it is unlikely that warm water immigrants would be introduced in this manner. But it is possible that meroplankton of subtropical fauna could be transported along the California coast by the Davidson Current (Bolin and Abbott, 1963), which flows northward during the fall and winter. However, Ford and Clark (1970) report that no "foreign" warm water species have been observed in the area subjected to thermal discharge from the Encina, California, power plant, and no mention of immigrant species is made in Reeves' (1970) review of ecological studies at the San Onofre, California, nuclear power plant.

Increased growth and protracted growing seasons have been reported for a number of species, mainly mollusks, living in environments receiving thermal waste from power plants (Ansell et al., 1964; Mann, 1965; Naylor, 1965b; Barnett and Hardy, 1969; Jensen et al., 1969).

A variety of north temperate marine bivalves which normally breed in the spring and summer can be induced to spawn during the colder seasons by elevating the temperature of the water if adequate nutrition is available (Loosanoff, 1945; Turner and Hanks, 1960; Sastry, 1966). This procedure is routinely utilized to maintain stocks of larvae of commercially important species all year round (Loosanoff, 1963). As would be anticipated from the above results, a number of species of marine and fresh water invertebrates have been found reproducing earlier in the year than normal in the heated water adjacent to power plant outfalls, and breeding seasons have been extended for species living in the northern part of their ranges (Naylor, 1965b; Jensen et al., 1969; Barnett and Hardy, 1969).

The Threat of Marine Thermal Pollution

Although virtually all industries produce waste heat, the electric power industry releases by far the greatest amount of heat to the environment. On the average, two kilowatts of heat are produced for every kilowatt of electricity generated by a steam-electric generating station (Jimeson and Adkins, 1971). Power plants are cooled by water drawn from rivers, lakes, estuaries, or coastal marine areas, depending on their location. In the plant, large volumes of cooling-water are passed through a chamber (the condenser) to cool steam exhausted from turbines which drive the electric generators. Heat transferred from the steam to the cooling-water in the condenser raises the temperature of the cooling-water five to 15 degrees centigrade, depending on flow rate. Unless atmospheric heat exchangers (cooling ponds or towers) are used, the cooling-water is returned, with its heat load, directly to the source (Electric Power and the Environment, 1970).

As of 1970, Southern California power stations sited on tidal waters discharged a daily total of 4.8 billion gallons of seawater averaging 10°C above ambient (Young, 1971). Young (1971) estimates that if all fourteen Southern California coastal power stations were operated at maximum load, a total of 3.6 sq mi (2,380 acres) of surface water would be elevated 2°F or more above ambient. An area of 0.26 sq mi (173 acres) would be expected to equal or exceed 10°F above normal.

The San Onofre nuclear power plant, located about 35 miles north of San Diego, is the closest steam-electric generating station (to the University of California, San Diego) with an offshore cooling-water outfall. A computer model (Intersea Research Corporation, 1972) has been developed to predict the excess temperature distribution which would be created by thermal discharge from the San Onofre nuclear generating station units 1, 2 and 3 (the 450 MW unit 1 is currently operating; units 2 and 3 are planned for the future and will each be 1150 MW). The area of the thermal field would depend on a number of factors, such as wind speed and direction, tide, current speed, and other atmospheric and hydrological conditions. The model predicts that the area encompassed by the 10°F, 6°F and 2°F isotherms will range from one-half to 80 acres, 4 to 400 acres and 80 to 2000 acres, respectively.

Thermal discharge into aquatic environments can only increase as more power plants are built to satisfy escalating energy demands. National electrical power production has approximately doubled every ten years since 1900, and this rate of increase is expected to continue or increase through 1990 (Löf and Ward, 1970). Population growth is partly responsible for this expanding need, but the major factor is rising per capita electrical consumption, which has grown about five times as fast as the population (Electric Power and the Environment, 1970). Most of the future demand for electricity will have to be met by steam-electric generation, as practically all of the economical sites for hydro-electric plants in the United States have been exploited and alternative electric power generating schemes (utilizing wind, tidal, solar and geothermal energy) are not expected to be commercially available or economically competitive for at least 20 years.

The majority of large power stations now under construction or in planning stages will be nuclear-fueled. In 1968, less than one percent of the total U. S. generating capacity was nuclear but, by the year 2000, nuclear power plants are projected to account for almost 70% of the national capacity (Nuclear Power and the Environment, 1969). For safety reasons, nuclear plants operate at lower steam temperatures and pressures than fossil-fuel plants; this makes the energy conversion less efficient. Not only do nuclear power plants reject more heat per kilowatt than fossil-fuel plants, but nuclear plants now being built or designed will be considerably larger. Thus, the environment adjacent to future nuclear plants will experience far greater thermal loading than is occurring near existing plants.

Many local, state and national regulatory agencies are in the process of adopting stricter water quality standards concerning temperature (Electric Power and the Environment, 1970). Power plants sited on freshwater bodies will be able to meet increasingly restrictive water temperature standards by employing cooling ponds or towers, but it is unlikely that atmospheric heat exchangers will be used with coastal power plants. Besides being visually unesthetic, cooling towers or ponds require considerable space, and coastal land is particularly expensive. Furthermore, the drift from evaporative saltwater cooling towers will contain the same salt concentration as the cooling-water itself; salt deposits from the drift might cause damage to animal and plant life at a considerable distance from the tower. Non-evaporative (dry) cooling towers circumvent this problem, but are far more expensive to build and operate, and the technology for dry towers with the capacity to serve greater than 100 megawatt power plants has yet to be developed (Electric Power and the Environment, 1970).

It appears, then, that once-through flow of cooling-water will remain the technique used to cool coastal power plants for at least the next two decades. Coastal electric utility companies may comply with new water quality standards by employing diffuser outfalls, which add the same amount of heat to the environment, but disperse the waste heat into a greater water mass with a concomitant reduction in the temperature rise of the receiving waters. In this way, the temperature of the heated water around the outfall could be maintained below the lethal limit of any member of the surrounding marine community, thus avoiding direct heat kills. However, chronic exposure to elevated but sublethal temperatures could, in the long run, lead to major changes in the biota by shifting competitive interactions, altering recruitment, growth, and reproduction of indigenous populations, or perturbing symbiotic relationships.

DESIGN OF THE EXPERIMENT, METHODS AND MATERIALS

Recognition of the pervasive influence of temperature on water-based ecosystems has prompted federal and state regulatory boards to require electric utility companies to monitor aquatic environments receiving thermal effluent. Field studies of thermal addition are also being conducted by various academic institutions and fishery and wildlife agencies (Edison Electric Institute, 1971; Ulrikson and Stockdale, 1971). Biological surveys carried out in these studies have usually employed one or both of the following sampling strategies: 1) synoptic sampling of the biota in the thermal field around the power plant outfall and in a "control" ambient temperature area outside the influence of the outfall, 2) sampling exclusively at the outfall site before and after construction of the power plant (Adams, 1968a, b, 1969; Geyer et al., 1968). Differences between samples taken in ambient and heated water are usually attributed, directly or tacitly, to the effect of temperature. However, statistical analysis is rarely applied to the data to determine whether the observed differences might be the result of sampling error. In addition, it is often not recognized that factors other than temperature associated with the discharge of power plant cooling-water might account for the sample differences. For example, the discharge of effluent often creates turbulent conditions which tend to maintain sediments in suspension, reducing light penetration.

The settlement of marine organisms is strongly influenced by current speed and light (Thorson, 1964); thus, observed sample differences could be associated with these physical factors, rather than with temperature. Antifouling agents such as chlorine gas and caustic descaling compounds are periodically added to the cooling-water. In the field it is difficult, if not impossible, to distinguish the effects of these toxic chemicals from the effects of elevated temperature.

In order to isolate the effect of elevated temperature from the influence of other factors associated with the operation of a power plant outfall, my research was conducted in the laboratory, where environmental conditions could be regulated.

Equal flows of unfiltered, larvae-bearing seawater, drawn from the end of the Scripps Institution of Oceanography pier, were continually passed through four identical 45 gallon aquaria. The water in two of the tanks was heated with immersion heaters. The other two tanks were not heated, and these two "ambient temperature tanks" served as the experimental control (Fig. 1; abbreviations and symbols are defined in the legend on p. vi).

Power plants in general, and nuclear stations in particular, operate at relatively constant capacity and raise the temperature of the cooling-water by approximately the same increment above ambient all year round. Yet, to my knowledge, there have been no previous laboratory studies of the effect of temperature elevated a constant increment above ambient. To create this effect, the immersion heaters were operated by an electronic proportional controller (designed by Earl Dolnick, Department of Physics, University of California at San Diego), which maintained the water in the heated tanks at 3°C above the temperature prevailing in the ambient tanks. The temperature in the heated tanks fluctuated exactly as it did in the ambient tanks (Fig. 2). It would have been ideal to establish a series of aquaria with increasing temperature elevations above ambient (such as, +1°C, +3°C, +5°C, +10°C, +15°C) but this was logistically unfeasable. Instead, I decided to investigate the effects of two typical thermal regimes created by the discharge of power plant thermal effluent into tidal waters, involving the same temperature increase. A low temperature elevation was selected in order to focus on sublethal, long-term effects. Three degrees Centigrade was chosen as a compromise between selecting a lower temperature which would correspond to a greater area of the thermal field around a power plant outfall and a higher temperature which would guarantee some observable thermal effects during the one-year experiment.

The heater in one tank (tank HH) was operated continuously. The heater in a second tank (tank HA) was operated on a cycle of six hours on - six hours off (Fig. 2). This intermittent heating simulated the effect of tides on the movement of effluent water away from a coastal power plant outfall. On the open coast and in estuaries, discharged cooling-water tends to flow in opposite directions during alternate tides. The semi-diurnal tides on the west coast of the United States cause the thermal plume to rotate around the outfall twice daily (Fig. 3). The majority of organisms living around a coastal power plant outfall are alternately subjected to elevated and ambient temperatures. Only the area in the immediate vicinity of the outfall is continually heated. It cannot automatically be assumed that intermittently increased temperature would have a less traumatic effect on marine biota than continually increased temperature. The greatest thermal stress in the heated water around a power plant outfall would be expected to occur during the summer, when ambient temperatures are maximal (Gunter, 1957; Kinne, 1963, 1970). As ambient temperature rises during the spring, marine organisms living in <u>continually</u> heated water would have the opportunity to adapt to gradually increasing, elevated temperature, and thus by summertime might be acclimated to the unusually high temperature prevailing around the outfall. However, it is possible that the process of acclimation to artifically increased temperature during the spring might be less effective in intermittently heated water where resident organisms would be returned to ambient temperature during a substantial portion of each day. If this was the case, marine organisms in intermittently heated water might be less physiologically prepared to withstand exposure to power plant thermal effluent during the summer than those which had been living in continually heated water. The HA regime was designed to test whether sublittoral marine animals respond differently to an off-on exposure to elevated temperature than to continual exposure to elevated temperature. The ratio of duration of exposure to heated water and ambient water decreases with distance from a coastal power plant outfall. The regime of equal alternating intervals of elevated temperature and ambient temperature was chosen because it represents the midpoint in the continuum between continual heating and no heating.

Considerable care was taken to maintain physical variables except for temperature as similar as possible in all four tanks. The flow rate of seawater into each tank was monitored by flow meters (with a ± 2% accuracy) and kept at the same level; two gallons per minute. This flow translates into a turn-over rate for seawater in the tanks of 64 times a day. The tanks were continually aerated; air flow into the four tanks was standardized with flow meters accurate to ± 3%. Water circulation was checked by introducing thousands of small chips of paper, punched out of computer cards, into the tanks. The seawater flow rate and flow pattern assessed in this way were similar in all the tanks, as was the amount of sand, silt, detritus and other debris which accumulated in the bottom of each tank.

The tanks were kept in complete darkness. Light strongly influences the settlement of larvae of benthic marine invertebrates (Thorson, 1964); relatively slight differences in light intensity between the tanks could lead to differential settlement. It was felt that the only way to adequately balance light levels was to eliminate light entirely. Since the experimental aquaria were not exposed to light, algal growth was precluded. This is, of course, artificial, but continual darkness is not entirely "unnatural", as the turbulence associated with the discharge of cooling-water from a power plant outfall often increases turbidity around the outfall to such an extent that little light penetrates below 5 m. This is often the condition at the San Onofre power plant, for example.

It was expected that comparable communities would develop in the two ambient temperature tanks if environmental variables other than temperature were successfully equalized among the four tanks. The communities in the two ambient tanks would not be identical, of course, but differences in population group properties, such as density, natality, mortality and size distribution, between populations in the two ambient tanks should not be statistically significant. If comparable communities did develop in the ambient tanks, then statistically significant differences between group properties of populations in the heated and ambient tanks could be specifically attributed to the effect of elevated temperature.

The experiment began on March 1, 1971. Settling plates, 30 cm x 30 cm asbestos (Transite) boards, were suspended in the tanks for periods of 5, 8, 13, 27, 38 and 52 weeks (Fig. 4). When a set of plates (one plate from each tank) was removed from the water, the community on each plate was systematically examined with a dissecting microscope. The front of the plate, that is, the surface which faced the center of the tank (see Fig. 1), was divided into nine 9 cm x 9 cm quadrats by placing a stainless steel wire grid over the plate. Individuals or colonies 1 mm or more in size were taxonomically identified and measured. Reproductive condition was determined, as well, for some species.

An IBM 1800 computer was utilized for data summary, statistical analysis and graphing. Computer programs were written to perform analyses of variance (ANOVAs) on abundance, size and reproduction data, and to plot size-frequency histograms for selected species. ANOVAs were also carried out for two measures of species diversity: 1) the number of species present, and 2) the Shannon-Wiener index, derived from information theory (Pielou, 1967):

$$H = - \Sigma p_i \ln p_i$$

where p_i is the proportion of individuals in the i^{th} species. The number of species does not take into account the relative abundance of the species, while the Shannon-Wiener index is dependent on both the number of species and the distribution of relative abundance of the species. The analysis of variance employed was a Kruskal-Wallis nonparametric ANOVA (Kruskal and Wallis, 1952) with the Nemenyi procedure for multiple comparisons (Nemenyi, 1963).

Information on abundance, size and reproduction was collected from all nine quadrats on the plates in the first five sets retrieved (Sets 1, 1b, 1c, 2 and 3; Fig. 4). To determine whether any species exhibited a strong preference for certain portions of the plates (e.g., edge, center, top, bottom) an ANOVA was performed on abundance data from the nine quadrats; the quadrats were the sample categories, the four plates constitued the replicates. No significant differential abundance among the quadrats was indicated for any species. Therefore, a subsample of the nine quadrats was taken for most species in subsequent sets. Even though no position effect had been demonstrated, the subsamples were not selected in completely random fashion; they were chosen to include the same number of edges from each of the four plates in a set (Fig. 5) to guard against the possibility of the most common position effect, edge preference or avoidance (Graham and Gay, 1945).

The long-term series, Set 1, 2, 3, 6, 9 and 12, was designed to provide information on the state of the fouling community after approximately 1, 2, 3, 6, 9 and 12 months in the three temperature regimes (ambient, intermittently increased temperature and continually increased temperature). In order to expand sample sizes for some species on the long term plates, additional specimens were collected from the back of settling plates, i.e., from the surface which faced the aquarium wall, and from the interior aquarium wall against which the settling plate hung (Fig. 1). Size ANOVAs were performed on data from these collections combined with data from the front of the settling plates. Abundance ANOVAs on these combined samples are not justifiable, however, as the three sample types, plate-front, plate-back and wall, cannot be considered replicates.

RESULTS AND DISCUSSION

Introduction

A diverse assemblage of organisms including sponges, coelenterates, ectoprocts, entoprocts, mollusks, annelids, arthropods, echinoderms and ascidians settled in the experimental seawater system (Table 1). Species included in Table 1 but not mentioned in the text were rare (i.e., less than five specimens were observed).

Data were gathered from 11 sets of plates: Sets 1, 1b, 1c, 1d, 1e, 2, 3, 3b, 6, 9 and 12. Sets 1, 1b, 1c, 1d and 1e spanned the interval from the coldest through the warmest seawater temperatures of the experiment (Figs. 6 and 7). Sets 1f, 1g, 1h, 1i, 1j, 3c, 3d and 6b were preserved but not examined in detail for the following reasons: 1) little settlement of marine organisms took place during the time these sets were suspended, 2) the other sets provided short-term data over the full range of temperature occurring during the year, and 3) the mass of data accumulated from the other sets was already overwhelming.

Tables 2 through 38 contain data for species or species groups counted on the plates. In these tables, the total number of individuals or colonies counted on each plate in a set is given in the top row. The following rows are mean and median values for 1) the number of individuals or colonies per quadrat, 2) the size of individuals or colonies, and 3) for ramifying species, the number of branches per quadrat (independent of the number of colonies). Mean values are presented because the arithmetic average is the most common measure of central tendency. Also, the difference between the mean and median gives an indication of the skew of the distribution of observations. The ANOVA employed was nonparametric (rank-based), and the appropriate measure of central tendency for ranked data is the median. Median values are, therefore, associated with the asterisks which represent significant differences in the tables. It should be pointed out, however, that the nonparametric ANOVA utilized identifies significant differences between sample rank sums (or mean rank sums), not actually between sample medians. This accounts for apparent discrepancies in the level of statistical significance for median contrasts with the same magnitude of difference (for example, see median size values for _Leucosolenia botryoides_, Set 12; Table 2), and for statistically significant differences between medians of the same value (for example, see median size values for _Crisia occidentalis_, Set 1d; Table 5).

Tables 39 and 40 give the results of ANOVAs on size data from combined samples. Because individuals on the aquarium walls and the back of plates were collected with the unaided eye rather than under the microscope, the average specimen size in the combined samples is greater than in front-of-plate samples. This bias of the combined samples was consistent among the tanks; therefore comparisons between combined samples are valid. Figs. 15, 16, 18 and 19 are computer-plotted size-frequency histograms of combined sample data.

Temperature Records

The experiment was initiated in March so that marine organisms settling during the spring, the season of maximum settlement at La Jolla (Coe and Allen, 1937) would have the opportunity to acclimate to gradually increasing seawater temperatures as summer approached. Fortuitously, the coldest seawater temperatures of 1971 occurred during the first week of the experiment (Fig. 6). An indication of the seawater temperatures to which each set of plates was exposed is given in Fig. 7. Seawater during spring (March, April and May) 1971 was colder than normal (Fig. 8), while June and July temperatures were warmer than the 50-year mean at Scripps Institution of Oceanography (Margaret K. Robinson, unpublished data records). The month of August was unusually warm, with a mean ambient seawater temperature 1.7°C higher than the 50-year mean. At the end of August, the water temperatures dropped rapidly and the succeeding fall and winter months were cooler than normal (Fig. 8) especially December, which was 2.0°C colder than the 50-year mean. The mean ambient tank temperature for the 52-week experimental period, 16.5°C, was somewhat lower than the 50-year annual mean at Scripps, of 16.9°C.

Protozoans

A variety of sedentary protozoans colonized the settling plates. Foraminiferans, suctorians, stalked colonial ciliates and folliculinids were particularly common. Protozoans were not enumerated, but qualitative observations were made on the abundance of some groups in Sets 1, 2 and 3. Generally, protozoans settled earliest and attained the highest densities on the HH plates in those sets; protozoan abundance was lowest on the ambient plates.

During the first four months of the experiment (March through June, 1971), thousands of the tube-building protozoan *Folliculina* sp., settled. *Folliculina* populations were densest in the A2 tank. There were approximately four times as many *Folliculina* on the A2 plates in Set 3 as on the A1 plate. This considerable difference in density of folliculinids between two ambient plates could have been the result of gregarious settlement, as free-swimming *Folliculina* larvae sense the presence of adults of their own species and settle preferentially next to them (Andrews, 1949). If more *Folliculina* settled by chance in the A2 tank during the early part of the settling season, an initially small difference in density between the ambient tanks could have been greatly expanded by subsequent gregarious settlement coupled with rapid asexual reproduction.

The settlement of *Folliculina* during July and August was relatively light. Virtually all of the *Folliculina* tests were vacant on the long-term plates retrieved at the end of summer (Sets 3b and 6). New settlers were not noted until the succeeding winter. There were no folliculinids on the Set 3c plates. Only a few hundred Folliculina settled during the time the Set 3d plates were suspended, and there was no noticeable difference in density between the plates.

Porifera

Three species of sponges settled on the plates. Most abundant was the cosmopolitan gray asconid, Leucosolenia botryoides, which grows from an encrusting base into branching colonies.

Leucosolenia size and abundance data are summarized in Table 2. The number of branches per quadrat is a summary statistic which reflects the abundance and size of colonies, and in the case of Leucosolenia, provided an index of biomass, because the branches of Leucosolenia were of comparable size on all the plates. Where dense mats had formed, as on plate A2 in Sets 3b, 6, 9 and 12, and plate A1 in Set 6, it was difficult to distinguish the individual colonies. For those plates, the colony abundance and size values may be inaccurate, but counts of branches per quadrat are correct.

No Leucosolenia were found on the short-term (5-week) plates suspended during the first three months, although a few colonies were present on the Set 3 plates. Heavier settlement took place during the following three months and, by the end of six months, numerous colonies were established on the plates in the ambient tanks (Sets 1e, 3b and 6; Table 2). Although there were considerable differences in the number of colonies per quadrat and in the number of branches per quadrat between the two ambient plates in Sets 3b and 6, the replicate variability within samples was high enough so that differences in these two statistics among the ambient plates were not shown to be significant. There was, however, a significantly greater number of colonies (P = .01) on the A2 plate in Set 6 than on the HA plate, and there were significantly more colonies on the A2 plate than on the HH plate in Sets 3b and 6 (Table 2).

As mentioned previously, the most reliable statistic for Leucosolenia is the number of branches per quadrat. Figure 9 is a plot of the median number of Leucosolenia branches per quadrat plus one for Sets 1, 2, 3, 6, 9 and 12 (the long-term series). (Unity is customarily added to numbers plotted on a logarithmic scale in order to avoid zero values.) Note in Fig. 9 that the greatest difference in biomass index between the plates from the ambient tanks and the HA and HH tanks occurred on the set removed at the end of August (Set 6). The biomass disparity between the ambient and heated tanks had decreased by nine months (Fig. 9) as a result of enhanced settlement and/or growth of Leucosolenia during the fall. It was not possible to differentiate between these possibilities because of the difficulty in delineating individual colonies. At the end of the year, the number of Leucosolenia branches per quadrat was comparable in the A1, HA and HH tanks. The consistently highest biomass index in the A2 tank was positively correlated with, and is perhaps a direct response to, the dense population of Folliculina sp. on the plates in the A2 tank.

The Leucosolenia biomass index decreased from Set 9 to Set 12 in all three temperature regimes (Fig. 9). Many temperate, colonial invertebrates, especially sponges and ectoprocts, have naturally occurring seasonal cycles of colony growth and colony deterioration (Ryland, 1970). Most of the colony growth takes place during the summer; a portion of the colony produced by summer growth "dies off" during the winter, resulting in decreased standing crop of the species.

The other two sponges, Leuconia barbata and Scypha ciliata, also have virtually cosmopolitan distributions (Burton, 1963). Scypha, an unbranched, globular heterocoel, mainly colonized the continually heated tank (Table 3). This species was short-lived; practically all the colonies had disintegrated by the end of the experiment. Scypha was first noted in Set 1d. Fifteen small, separate colonies of comparable size were found in five quadrats on the HH plate. This suggests that the concentration of Scypha in the continually heated tank did not arise by the asexual reproduction of a single larva (or a few larvae) which had, at random, been diverted to that particular tank. A more probable explanation is that considerable numbers of larvae passed through each tank, but that settlement was much more intense in the continually heated water than in the other temperature regimes. Leuconia, a large orange branching heterocoel, was also found almost exclusively in one tank, the HA tank (Table 4).

These results indicate that relatively small differences in temperature may strongly influence the settlement and/or survival of some species of sponges. If this is true, sponges would make good candidates for use as "indicator species".

Coelenterata

The only coelenterate which appeared in the experimental seawater system was the anthozoan, Diadumene sp. Three specimens of this pink anemone were discovered, all attached to the inside walls of the continually heated tank.

The absence of hydroids, which are normally among the most common fouling organisms (Woods Hole Oceanographic Institution, 1952) and were prevalent in earlier studies at La Jolla (Coe, 1932; Coe and Allen, 1937; Aleem, 1957) was surprising. However, Haderlie (1968, 1969) has also recently reported a paucity of hydroids on settling plates in Monterey Bay.

Ectoprocta

Ectoprocts were the most abundant macroscopic organisms on the plates. Two members of the family, Crisiidae, *Crisia occidentalis* and *Filicrisia franciscana*, were especially conspicuous. These bushy cyclostomes are common intertidal and subtidal fouling species along the west coast of North America (Osburn, 1953).

Branching ectoprocts such as *Crisia* and *Filicrisia* have a relatively constant number of individuals (zooids) per branch (Hyman, 1959). Thus, the number of branches is directly proportional to the number of zooids, and the number of branches per unit area can be used as an index of zooid density as well a biomass.

Size and abundance data for *Crisia* are presented in Table 5. The values for median number of *Crisia* branches plus one for the long-term series of sets have been plotted in Fig. 10. The values for the two ambient tanks in Fig. 10 differ somewhat, but none of the differences are statistically significant (Table 5) and the A1 and A2 curves have a similar trend. This implies that, with respect to the settlement and growth of *Crisia* on the long-term series of plates, the experiment was adequately controlled. The HA curve in Fig. 10 approximately parallels the ambient curves, except that after 12 months the *Crisia* zooid density index was significantly greater (P = .01) in the HA tank than in the HH and A1 tanks.

The history of Crisia in the continually heated tank is particularly interesting. Eight out of nine of the significant differences in median number of branches per quadrat for the long-term series (Table 5) were between the HH tank and one of the other tanks. During the spring, the settlement and growth of Crisia was greatest in the HH tank. By the end of one, two and three months after the beginning of the experiment, more Crisia colonies had settled in the HH tank than in any other, and the HH colonies had the largest average size. Consequently, the median number of branches per quadrat in the HH tank was by far the greatest for Sets 1, 2 and 3. By the end of the summer (Set 6), however, the HH zooid density index was the lowest of the four tanks, and at 9 and 12 months was even further depressed relative to the other tanks.

The experimental control for the 5-week sets of plates was relatively poor, i.e., data from the two ambient tanks were often dissimilar (see Table 5). Stochastic (random) processes, perhaps coupled with gregarious settling behavior (Bayne, 1969), may have been responsible for the short-term disparities.

Results for Filicrisia on the long-term series of sets agree remarkably well with the Crisia results. Table 6 contains the size and abundance data for this species; Fig. 11 is a plot of the zooid density indices for the long-term series of sets. As in the case of Crisia, the control tanks in the long-term sets have comparable values, the HA curve roughly parallels the A1 and A2 curves and ends with the highest zooid density index, the *Filicrisia* population developed most rapidly in the HH tank during the first three months and then declined sharply after six months.

The large average colony size for *Filicrisia* on the A2 plate in Set 3 is due to a relative paucity of small colonies on that plate compared to the other plates. The largest colonies in Set 3 were on the HH plate, but a preponderance of small colonies reduced the HH plate average colony size to the least of the four plates in Set 3.

The majority of ectoprocts brood their larvae. In the family Crisiidae, brooding is accomplished in a chamber, the ovicell, formed by a specialized zooid, a gonozooid. Gonozooids in *Crisia* and *Filicrisia* colonies produce inflated pyriform ovicells which are easily detected. Ovicells first appeared on *Crisia* and *Filicrisia* colonies in Set 3. The five largest *Crisia* colonies (four of these were on the HH plate, one on the HA plate) had ovicells. Ovicell formation was also a function of colony size for *Filicrisia* and, as with *Crisia*, the largest colonies in Set 3 were on the HH and HA plates.

The stoloniferous ectoproct order Ctenostomata was represented by two species: *Amathia distans* and *Bowerbankia gracilis*. The zooids in both these genera bud directly from the stolons; *Amathia* formed tangled masses of stolons which hung from the plates, while *Bowerbankia* stolons were mostly repent.

Amathia occurred mainly in the HH tank and was never found in either ambient tank (Table 7). Although a few colonies were located on plates from the HA tank, non-zero values of median number of branches per quadrat occurred only in the continually heated tank (Table 7; Fig. 12). The response of *Amathia* to elevated temperature makes sense in terms of its geographical range. This species is distributed circumtropically, but has rarely been reported from temperate waters (D. F. Soule, personal communication).

Bowerbankia was first noted on the three sets removed at the end of the summer (Sets 1e, 3b, and 6; Table 8). Colony abundance and size data were not collected because the stolons were practically transparent and it was often impossible to tell where one colony ended and another started. *Bowerbankia* occurred in large numbers on every plate in Set 6, yet was present only on one plate in Set 1e and on two plates in Set 3b. This suggests that few *Bowerbankia* larvae settled in the tanks during the late summer, and that the high zooid densities were produced by asexual reproduction. *Bowerbankia* was so abundant at 9 and 12 months that it appeared as a light brown fuzz on the long-term plates. The zooids were too dense to count accurately; only the relative abundance was determined (Table 8). The highest zooid densities were consistently found on the HA plates.

Six species of cheilostomes were found in the experimental seawater system (Table 1). Only one colony of

Scrupocellaria sp. was observed (attached to an exterior wall of the A2 tank). Membranipora serrilamella occurred in all the tanks, but only on smooth plexiglass surfaces.

Three of the cheilostomes counted on the plates were anascans: Aetea anguina, Bugula mollis and Scruparia ambigua. Although Aetea appeared in appreciable numbers only on six plates (Table 9), it is obvious from the results of Sets 1e, 3b and 6 that this species had no difficulty settling and surviving in the high temperatures which prevailed in the heated tanks toward the end of the summer. This would be expected, since Aetea anguina is virtually cosmopolitan in temperate and tropical waters (Osburn, 1950).

Of all the bryozoan species occurring on the California coast south of Monterey, Bugula neritina is probably the most prominent (Osburn, 1950), yet this species failed to settle in the experimental seawater system. The explanation might be that this species avoids settling in darkness. However, in an experiment performed by McDougal (1943), B. neritina settled most abundantly at the lowest light intensities.

A less common species of Bugula, B. mollis, was, nevertheless, very abundant on some of the plates (Table 10; Fig. 13). The most striking feature of the B. mollis data is early settlement in the continually heated tank. B. mollis larvae began colonizing the HH tank six weeks before appearing in the other tanks. Colonies of B. mollis in the HH tank were reproductively active before settlement had even taken place in the ambient and intermittently heated tanks; over half of the Bugula colonies on the HH plate in Set 3 contained ovicells.

Until recently, the spawning season of an ectoproct was normally considered to be that portion of the year during which the larvae were known to settle. It has now been shown (Ryland, 1967) that colonies of a number of temperate ectoproct species with short-lived larval stages, such as Bugula, contain embryos throughout the year, even though larval settlement occurs only during a restricted portion of the year (usually in the warmer months). This suggests that larvae may be released during seasons when settlement has not been observed. But, as Ryland (1970) points out, it remains to be demonstrated that larval release is occurring during the non-settling period. The appearance of B. mollis in the continually heated tank six weeks prior to its settlement in the ambient tanks is evidence that field populations of this species are, in fact, releasing larvae considerably earlier than would be predicted from the settling season in ambient temperature water.

The major settlement of B. mollis in the A1, A2 and HA tanks took place from the middle of June until the end of July. The difference in the number of colonies which became established during this time in the two ambient tanks was more than an order of magnitude (Table 10). The consistently lower frequencies on the A2 plate than on the A1 plate in Sets 1d, 1e, 3b, 6, 9 and 12 may have been the result of restriction of larval settlement by the dense cover of Folliculina on the A2 plates. However, the growth of colonies which succeeded in establishing on the A2 plates was apparently unaffected. In Sets 1e and 6, the largest colonies on both ambient plates were approximately the same size. The significantly greater median colony size on the A2 plate was due to a lesser proportion of small colonies on that plate.

The vast majority of *B. mollis* colonies on the HH plate in Set 1d had only one or two branches. Presumably, the growth of *B. mollis* colonies which settled in the continually heated tank during the first two or three weeks after the Set 1d plates were placed in the water was halted by the high temperatures which prevailed during the latter portion of the suspension period (Fig. 6). Brown body formation, a characteristic response of young colonies to unfavorable conditions (Ryland, 1970), had occurred in all of the zooids on the HH plate; brown bodies were not present in zooids on the other Set 1d plates.

Although comparable numbers of *B. mollis* settled on the A2 and HA plates in Sets 1d and 1e, the HA plates in Sets 3b, 6, 9 and 12 were practically devoid of *Bugula*. No explanation can be offered for the absence of *B. mollis* from the long-term HA plates. There is a remote possibility that a species of opisthobranch mollusk which preys on _Bugula_ was active in the HA tank and not in the other tanks.

The abundance and size of _Scruparia_ _ambigua_ colonies were greatest in the ambient tanks at three months (Table 11; Fig. 14). Zooid density in both heated tanks peaked at a significantly lower level than in the ambient tanks and the peak was evidently reached earlier in the year in the continually heated tank than in the other three tanks.

Reproduction in _Scruparia_ and _Aetea_ was not checked because the ovicells are evanescent and difficult to detect.

The only ascophoran which settled on the plates was _Cryptosula_ _pallasiana_, a common encrusting form ranging from central Mexico to Alaska along the Pacific west coast (Osburn, 1952). Young colonies are generally flat and disk-shaped, while older colonies have a tendency to become asymmetrical, sometimes rising off the substrate in frills. The zoecia (cases within which the polyps live) are rectangular and of equal size (0.5 x 0.33 mm); each zoecium occupies an area of 0.17 mm^2. An actual count was made when the number of zooids per colony was less than 20; when the colony contained more than 20 zooids (and many colonies contained hundreds), zooid number was estimated by dividing the area of the colony by 0.17 mm^2.

Cryptosula settled most abundantly during the peak summer temperatures (Table 12). There is some indication that the settlement of _Cryptosula_ was inhibited in the continually heated tank during the summer. In Set 12, the HH plate had less than half as many colonies as any other plate; the colonies were so large, however, that the number of zooids was by far the greatest on the HH plate.

Entoprocta

Representatives of both families of marine entoprocts settled on the plates (Table 1). Only one colony of *Pedicellina cernua* (A1 plate, Set 3b) was observed. *Barentsia discreta* began appearing on the plates at the end of the summer (Table 13); a number of distinct colonies was present on plates in Sets 3b and 6. *Barentsia* was so abundant on the plates in Set 9 that the extent of most colonies could not be delineated. *Barentsia* was even denser on the Set 12 plates. Since zooid enumeration would have been inaccurate and time-consuming, rank order of abundance on the four plates in Set 12 was determined instead (see Table 13). By the end of the experiment, zooid density of *Barentsia* was greatest in the intermittently heated tank.

Specimens of the genus, *Loxosoma*, were only observed on plates removed at the end of summer, and were most abundant on the HA plates (Table 14).

Mollusca

The tiny tubular shells of the genus *Caecum* began settling during the second half of the experimental period

(Table 15) and were most abundant in the HH tank. These gastropods could not be considered common in the ambient tanks, yet it is remarkable that none of the total of 35 specimens counted were found in the HA tank.

Size and abundance data for the half-slipper shell, Crepipatella lingulata, on the front of the settling plates are given in Table 16; data on combined samples are presented in Table 39. Even though the statistical significance of abundance differences between combined samples from the four tanks cannot be established, there was a definite paucity of Crepipatella in the Set 6 HH combined sample. If the reduced population size in the HH tank at the end of the summer was a consequence of thermal stress, no such effect occurred in the intermittently heated tank (See Fig. 15).

Crepipatella broods its larvae. Adult specimens on the front of settling plates were lifted off the substrate to check for masses of minute veligers under the shell. A total of 13 Crepipatella in Sets 9 and 12 were found with brooded larvae: four in the A1 tank, one in the A2 tank, three in the HA tank, and five in the HH tank. This sample is too small to reveal anything except that Crepipatella began reproducing in all tanks by the end of the experiment.

The scaled worm shell, Serpulorbis squamigerus, began settling during the summer (Table 17). Over half of the specimens in Sets 6, 9 and 12 settled on Cryptosula pallasiana colonies. In one case, six Serpulorbis were growing on a Cryptosula colony with an area of less than 2 cm^2.

Opisthobranchs were relatively rare and were not counted on the plates because of their motility. Eleven species were observed crawling around in the aquaria (Table 1). The abundance of each species in the four tanks was recorded periodically. There were no striking differences in numbers among the four tanks.

Bivalves were the most conspicuous mollusks on the plates. Specimens less than 2 mm long were difficult to identify and were treated as one group. None of the sets had significantly different numbers of these minute, unidentified bivalves (Table 18).

The delicately sculptured agate chama, _Chama pellucida_, was apparently unaffected by elevated temperature. _Chama_ had a similar frequency on the 3- and 6-month plates retrieved at the end of the summer (Table 19), and there were no significant size differences between combined samples of _Chama_ taken at 6, 9 and 12 months.

The grayish-white nestling clam, _Hiatella arctica_, occurred on all the long-term plates and on most of the short-term plates (Table 20). At two months, _Hiatella_ in the HH tank were significantly larger than in the A2 tank (Tables 20 and 39). Although there were no significant size differences at three months, specimens in the combined sample from the HH tank still had the largest median size.

Judging from the results of Set 1d, almost twice as many individuals colonized the continually heated tank as any other tank during the major settling period of the first six months. It appears, though, that survival was relatively poor in the continually heated tank; Hiatella was least abundant on the HH plate in Set 6 (which was removed seven weeks after Set 1d). The combined Hiatella samples (Table 39) follow the same pattern: greatest abundance in the HH tank prior to summer, fewest numbers after summer. The size-frequency histograms for the HH tank in Set 6 (Fig. 16) show that the number of individuals in practically all size-classes was reduced relative to the ambient tanks. This was not the case for the HA tank.

In Set 9, the size ANOVAs indicate that the ambient tanks had significantly larger Hiatella than the continually heated tank (Tables 20 and 39), but the size-frequency histograms for the Set 9 combined samples (Fig. 16) are not strikingly different, and the populations in the four tanks appeared even more similar by the time Set 12 was removed.

A preponderance of juveniles (small shells) on the A2 plates in Sets 1d and 3b accounts for the small average size of Hiatella on those plates. The concentration of individuals on the A2 and HH plates in Set 3b is inexplicable.

Hiatella collected from the wall adjacent to the Set 3 plate in each tank were examined for the presence of ova or spermatozoa (Fig. 17). Hunter (1949) reports that the majority of east Atlantic Hiatella larger than 7 mm are ovigerous. This was also true for Hiatella examined in this work. Breeding appears to have been initiated at the same shell size in all tanks (Fig. 17). Hiatella grew most rapidly in the continually heated tank during the spring and reproduction presumably began earliest in that tank.

Although Hiatella is capable of boring into hard substrates, it did not drill into the asbestos plates. Small holes were, however, bored into the plates by members of the family Pholadidae. None of the pholads grew larger than 2 mm in cross-section (Table 26) and, consequently, all were too small for generic identification. Pholads were unsuccessful at colonizing the plates in the long run; there were no live specimens on the Set 12 plates.

Three species of scallops, Aequipecten aequisulcatus, Hinnites multirugosus and Leptopecten latiauratus settled in the tanks. The purple-hinge rock scallop, H. multirugosus, began appearing in the seawater system at about three months (Table 21). Juvenile Hinnites are either lightly attached by byssus threads, or are unattached and can "swim" by rapid contraction of the shells. Adult specimens have the right valve permanently attached to the substrate. The size at which Hinnites cements to the substrate varies widely; Yonge (1952) speculates that permanent attachment may be associated with sexual maturity. The three individuals which attached permanently to the plates did so at a hinge-length of around 2 cm. Hinnites settled in all the tanks during the spring (Sets 1, 2 and 3; Table 29), but no live rock scallops were found in the continually heated tank at the end of the summer (Set 6; Table 39); the sole specimen from the HH tank was an empty shell.

Most of the kelp scallops, Leptopecten latiauratus, attached at the top of the tanks near the over-flow slots. Because of this, far more specimens were present in the combined samples (Table 39) than on the settling plates (Table 22). Scallops as a group generally have low thermal tolerance (Altman and Dittmer, 1966). It seems that Leptopecten, as well as Hinnites, responded negatively to increased temperature during the summer. There were less than half the number of Leptopecten in the heated tanks as in the ambient tanks at the end of the summer, and both specimens in the Set 6 combined sample from the HH tank were empty shells (Table 39).

The speckled scallop, Aequipecten aequisulcatus, was discovered living on bottom in each of the two ambient tanks in November 1971. Both specimens survived until the experiment was terminated, reaching a hinge-line length of 35 mm in the A1 tank and 28 mm in the A2 tank.

The fragile white clam, Kellia laperousii, which settled sparsely on the front of the plates (Table 23), was more abundant in the spaces between the back of the plates and the interior aquarium walls. This accounts for the much greater numbers in the combined samples (Table 39). No significant differences in abundance or size are indicated in Table 23, yet it is noteworthy that considerably more *Kellia* were present in the heated tanks (Set 3 combined samples; Table 39) than in the ambient tanks at the beginning of June, while the opposite was true at the end of August (Set 6; Table 39).

Of the 16 species of bivalves which settled in the seawater system, the sea mussel, *Mytilus*, is of particular interest and importance. Mussels are often the most conspicuous members of the intertidal climax community on rocky shores along the Pacific coast of North America (Soot-Ryen, 1955). Clumps of mussels provide a protected habitat for a wide variety of marine invertebrates which live among the byssus threads. Two species occur on the west coast: *M. californianus* and *M. edulis*. The former is found predominantly on exposed coast. The latter is also found on the open coast, often mixed in with *M. californianus*.

M. edulis occurred in similar numbers in all four tanks (Tables 24 and 39). The size-frequency histograms of data from combined samples (Fig. 18) indicate that increased temperature did not significantly alter the settlement or survival of *Mytilus* during the year-long experiment. Growth, however, was affected at elevated temperature. *Mytilus* grew more rapidly in heated water during the spring. Populations in the HH and HA tanks ranked first and second, respectively, in median size for Sets 1, 2 and 3. But by the time Set 6 was removed, *Mytilus* in the HA tank ranked third in size, and the HH tank *Mytilus* had the lowest rank (fourth). Differences in the size of mussels from the heated and ambient tanks at the beginning of the summer (Set 3) and at the end of the summer (Set 6) were highly significant (Table 39).

During the fall and winter (1971-1972), mussels in the intermittently heated tank grew faster than in any other tank; the growth of *Mytilus* in the continually heated tank was approximately the same as in the ambient tanks. By the end of the experiment, the *Mytilus* population in the HA tank had the largest median size, and the HH tank *Mytilus* had the smallest median size (Table 39).

The presence of a few plantigrade (recently settled) mussels in the Set 12 combined samples (See Fig. 18) obscures the significance of size differences between the majority of *Mytilus* from the four tanks. When mussels less than 20 mm (two standard deviations below the mean of the pooled Set 12 combined *Mytilus* samples) are eliminated from consideration, a size ANOVA indicates that both the A1 and A2 samples are significantly larger (P = .05) than the HH sample, and that the significance of the size difference between the HA and the HH samples is even larger (P = .01).

The *Mytilus* specimens in the Sets 6, 9 and 12 combined samples were opened and checked for gonadal development. When gonads were located, a smear of mantle tissue was microscopically examined for ova or spermatozoa. The presence of gametes corresponds to a degree of genital development equivalent to stage 2 or stage 3 in the classification scheme of Chipperfield (1955). There was no indication that increased temperature altered the size at which gametogenesis began. Virtually all of the individuals from the four tanks greater than 40 mm in length contained ova or spermatozoa. The mussels which settled at the beginning of the experiment reached that length at approximately the same time in all four tanks, because faster growth in the heated tanks during the spring was offset by slower growth in those tanks during the summer.

A more detailed examination of the gonads would be required to determine whether spawning was affected by increased temperature (Seed, 1969). The *Mytilus* samples have been preserved pending histological examination of the gonads.

The only previous laboratory study which has considered the effects of intermittently increased temperature involved *Mytilus edulis* as the experimental animal. Pearce (1969) found that *M. edulis* exposed to a constant temperature of 30°C died within 12 hours but, if the temperature was regularly cycled between 20°C and 30°C, mussels survived a total exposure of more than 1000 hours at 30°C. In my experiment, the highest daily average temperature which occurred was 28°C. *M. edulis* was not killed at this temperature.

Because Mytilus edulis larvae may be damaged by passage through a power plant's condenser, the fact that this species does not foul the discharge conduits cannot be considered evidence that mussel settlement would be restricted in the field by temperatures increased as much as 8 - 10° C above ambient. Pearce (1969) reports that the larvae of M. edulis, unlike those of most invertebrates studied, are considerably more tolerant to increased temperature than the adults. However, Pearce and Young's study at the Northport power plant indicates that an elevation of 15°C above ambient may completely eliminate mussel settlement.

Several thermal kills of field populations of mussels exposed to thermal effluent have been reported (Arndt, 1968; Biological Effects of Thermal Pollution, Northport, New York, 1970; Studies on the Effects of a Steam-Electric Generating Plant on the Marine Environment at Northport, New York, 1971). In these instances, the thermal plume was evidently greater than 5°C above ambient, and lethal temperatures were reached only during the summer.

Mytilus edulis is the only frequently occurring species in my experimental community for which temperature tolerance information exists. As mentioned previously, Henderson (1929) reported a lethal temperature of 40.8°C. However, in a recent laboratory study of longer duration, Read and Cumming (1967) found 30°C to be the upper lethal temperature. Wells and Gray (1960) showed that M. edulis in the western

Atlantic is killed by 26.7°C. A lethal temperature of this order may also determine the southern limit of the species in the northeast Pacific, as it does not range past the tip of Baja California (McLean, 1969), where summer temperatures exceed 29°C (Lynn, 1967).

Coe (1932) reported that larvae of the native oyster, Ostrea lurida, attached to solid substrates at La Jolla, California, only when the water temperature was greater than 16°C and that the settling season of Ostrea extended roughly from April through October, with peak spawning usually during June, July and August. Water temperature in the continually heated tank exceeded 16°C during the second week of March (Fig. 6), but no Ostrea spat settled in that tank until 16°C was reached in the ambient tanks (Table 25). When, during the following winter, the ambient tank temperature dropped below 16°C, there was no settlement in any tank (specimens less than 12 mm in the Set 12 combined samples were all empty shells - Fig. 19).

All the oysters examined on the plates in Set 1d were alive. By the time the Set 3b plates were removed, considerable Ostrea mortality had taken place in two of the tanks: 21 out of the 58 specimens in Set 3b were empty shells. Approximately half of these lacked the top valve, perhaps due to predation by decapod crabs. In most of the dead specimens with both valves present, drill holes through the top valve indicate predation by a mollusk, most likely a gastropod. The only mollusk in Table 1 which could be responsible is Poulson's rock shell, _Ocenebra poulsoni_. However, only one _O. poulsoni_ was observed: a 2.5 cm specimen in the HH tank during October 1971.

The significant Ostrea size difference between the A2 and HA plates in Set 1d is inexplicable (unless it occurred by chance). The size disagreement between the two ambient tanks in Set 3b was due to the presence of 10 dead specimens (all less than 10 mm) in the A1 tank, and none in the A2 tank.

There were no significant differences in oyster abundance in Sets 6, 9 and 12, although the greatest number were found on the HA plates (Tables 25 and 40). Size-frequency histograms of data from the front and back of the Set 6, 9 and 12 settling plates are presented in Fig. 19. In Sets 6 and 9, the largest average _Ostrea_ size occurred in the HA tank; the size differences in Table 40 remain significant at the same probability levels when dead specimens are eliminated from the analysis. If dead _Ostrea_ are removed from consideration in Set 12, there is no longer a significant difference between the size of _Ostrea_ on the HA and HH plates, but the probability levels in Table 40 remain unchanged for the A2-HH and A1-A2 contrasts.

Oysters are generally eurythermal (Altman and Dittmer, 1966), and _Ostrea lurida_ is evidently no exception. Adams (1968b) reports that _O. lurida_ settled and flourished in the discharge canal of the Humboldt Bay nuclear power plant in northern California. *Ostrea* has also been cultured successfully to a marketable size in the discharge basin of the Encina power plant in San Diego County (G. Schumann, personal communication). The American oyster, *Crassostrea virginica*, appears to be unaffected by exposure to temperature elevated on the order of 3°C. Roosenberg (1968) studied *C. virginica* in the Patuxent River Estuary before and after the Chalk Point power plant began operation. The growth, survival and gonadal development of *C. virginica* living within the 2°-5°C isotherm above ambient was comparable to that before the power plant began discharging heated water.

The abalone jingle, *Pododesmus cepio*, was common in all four tanks at the beginning of the summer. On May 20, 1971, 23 *Pododesmus* were collected from the wall adjacent to the Set 3 plate in the A1 tank, 16 were collected from the analagous wall in the A2 tank, and comparable samples from the HA and HH tanks contained 30 and 16 individuals, respectively. *Pododesmus* survived through the summer only in ambient and intermittently heated water (Tables 27 and 40); the single specimen on the HH plate in Sets 6 and 9 was an empty shell. Evidently intermittent heating was also a suboptimal regime, since no specimens were present on the plates from the HA tank at 9 and 12 months.

The disappearance of *Pododesmus*, *Hinnites* and *Leptopecten* from the continually heated tank during the summer might be expected if, in La Jolla, they are living closer to the southern limit of their range than are *Chama* and *Ostrea*, which were apparently unaffected by continually increased temperature during the summer. However, the reported southern boundaries for all these bivalves appear to be identical (McLean, 1963); none are known to range below Baja California.

Annelida

Nine families of polychaetes were represented in the material collected from the experimental seawater system (Table 1). Only two families, Spionidae and Serpulidae, were common.

Species in the spionid genus, *Polydora*, build a branching tube made of sand grains and detritus cemented together with "mucus". Initially, I attempted to measure both tube length and length of the worm itself. Unfortunately, the worms could seldom be removed intact, and the ramifying form of the tube made accurate length measurement difficult. These determinations were, consequently, discontinued for sets 6, 9 and 12. The considerable disparity in *Polydora* density between the ambient plates within sets in the long-term series (Table 28) renders the significance of other abundance contrasts for *Polydora* questionable.

The permanent unbranching calcium carbonate tubes of serpulids could be easily and accurately measured. The tube of _Spirobranchis spinosus_ has a striking purple crest, and this species could often be positively identified at a tube length of less than 5 mm. It was usually not possible to differentiate between _Eupomatus gracilis_ and _Serpula vermicularis_ until tube length reached about 30 mm. These two species, therefore, were treated together in Sets 1 and 2 (Table 29).

With a single exception, all the serpulids present on the plates appear to have settled during the first five weeks of the experiment (Tables 29, 30, 31, 32). Comparable numbers of serpulids settled in the four tanks, and the survival of _Eupomatus_ and _Spirobranchis_ appears to have been unaffected by increased temperature.

Growth of serpulids in the spring was most rapid in heated water. The median size of serpulids on the HH plate in Set 2 was significantly greater than on either ambient plate (Table 29); average size on the HA plate was intermediate between the HH and ambient values. There were no significant size differences among the plates in Set 3 for the most common serpulid, _Eupomatus gracilis_, although the two longest tubes were on the HH plate (Table 30). This situation was reversed by the end of the summer; the HH plate had the smallest average tube length in Set 6 (Tables 30 and 40).

Indications of predation on Eupomatus were first noted in Set 6. Two Eupomatus tubes on the HA plate and one on the HH plate were empty, and the anterior portion of the tubes had been broken. Of the species in Table 1, only the brachyuran decapod crabs, Lophopanopeus and Pilumnus, are powerful enough to have caused the damage. A total of six broken empty tubes were found on the Sets 9 and 12 plates. A few tubes had sustained damage without the worm being killed, and partial regeneration of the tube had taken place. In these instances, the size of the tube was recorded as length of the new growth plus length previous to predation.

Tables 30 and 40 contain information on all of the Eupomatus tubes on the plates, regardless of the presence or absence of a living worm in the tube. A similar pattern emerges, however, if only tubes with viable worms are considered. The largest average tube size in Sets 9 and 12 occurred on the HA plate; the A1, A2 and HH plates had about the same average size at 9 and 12 months.

Eupomatus gracilis on the front of the Set 3 settling plates were extracted from the tubes and examined for the presence of gametes. As all the specimens contained eggs or sperm, it was too late to tell whether reproduction had been initiated earlier in the heated water than in ambient water.

Two of the 17 _Serpula_ tubes on the front and back of the ambient plates and all three on the HA and HH plates in Sets 9 and 12 were empty (Table 40). The presence of 15 living _Serpula_ from the ambient tanks in these sets, compared to no living specimens on plates from the heated tanks, indicates that the survival of this species was reduced at a continually or intermittently increased temperature of 3°C above ambient.

Arthropoda

Acorn barnacles were far less abundant than would have been expected from the results of previous epifaunal studies in shallow water at La Jolla (Coe, 1932; Coe and Allen, 1937; Aleem, 1957; Fager, 1971). The occurrence of shells of cyprid larvae is given in Table 33. Table 34 contains size and abundance data for balanoid barnacles too small to classify to species. Only a few of the barnacles which settled on the plates grew large enough to be identified to species; in all the sets examined, only 8 _Balanus glandula_, 14 _B. pacificus_, 2 _B. tintinnabulum_ and 20 _B. trigonus_ were recorded. There were no qualitative trends with respect to differential size or abundance in the three temperature regimes, either when the above species were considered separately or together (Table 35). Barnacle survival in the tanks was poor; a total of six barnacles was found on all four 12-month plates.

Two weeks after the experiment began, small goose-neck barnacles, _Pollicipes polymerus_, were observed growing along the overflow slots of the continually heated tank. The outside walls of the HH tank were nearly covered with _Pollicipes_ by six weeks. At that time, a few smaller specimens were observed on the walls of the HA tank, but it was not until eight weeks that goose-neck barnacles began appearing on the walls of the ambient tanks. There were approximately equal numbers of _Pollicipes_ on the walls of all four tanks when the 3-month plates were removed. Goose-neck barnacles, unlike acorn barnacles, do not actively beat their cirri, but depend upon currents to carry food to them. The water in the tanks evidently moved too slowly for the survival of _Pollicipes_; a few juvenile specimens were found on the plates (Table 36), but there were no adults.

Barnacle reproduction can be easily checked by examining the brood pouch but, unfortunately, the number of adults on the plates was too small to provide a meaningful sample.

Caprellids were also less abundant than expected. The three species of caprellids (Table 1) accounted for a total of 17 individuals on all the plates examined.

Initially, an attempt was made to discriminate between harpactacoid and cyclopoid copepods. However, in retrospect, I doubt my ability to make this distinction in a number of cases, therefore, all copepods were considered together. Lumping data in this way can obscure individual species trends, but the effort necessary to learn copepod taxonomy and to re-examine the samples is not warranted. Copepods were abundant on plates in some of the sets (Table 37) but there was often a large difference in frequency between the two ambient plates within a set. No clear picture of the response of copepods to increased temperature emerged. The size and abundance data for gammarid amphipods (Table 38) likewise exhibit no trends.

Ascidiacea

Three species of solitary ascidians and colonial ascidians of three different colors settled in the seawater system. A total of 19 individuals of *Ascidia ceratodes*, a solitary species with a transparent tunic, occurred in seven sets. Although there were too few specimens in any single set for statistically significant differences to appear, the occurrence of two *Ascidia* on the HH plate in Set 6 implies that this species is not particularly sensitive to elevated temperatures. A similar ascidian, *Ciona intestinalis*, settled and reproduced throughout the year in a dock heated by thermal effluent in Swansea, South Wales (Naylor, 1965a). Although temperature records were not presented in Naylor's report, the water in the dock was apparently 5-6°C above ambient.

Only one specimen of *Styela montereyensis* was observed. *S. barnhardi* was found on five plates in Sets 3, 9 and 12.

Twenty-four of the 37 individuals occurred on one plate (A1; Set 12). Molgula verrucifera was found on five plates in Sets 6, 9 and 12 and, as in the case of S. barnhardi, there was a predominance of individuals on one plate (88 of the 101 specimens were on the A2 plate, Set 12). Solitary ascidians are also commonly found in clumps in the field. Since asexual reproduction of solitary ascidians is unknown, gregarious settlement is indicated (T. Ermack, personal communication).

A single colony of a red colonial ascidian (area = 36 mm^2) occurred on the HH plate in Set 6. In this same set a yellow colonial ascidian (area = 78 mm^2) was present on the A1 plate. At nine months, a white colonial ascidian was observed on the 12-month plate in the HA tank; when this plate was removed three months later, the colony covered an area of 6000 mm^2, almost one-tenth of the plate.

Settlement, Growth, Reproduction and Survival of Epifauna

There were twenty-two species of macroscopic invertebrates which were sufficiently abundant on the settling plates to determine that the experimental control was adequate. The settlement of most of these species was comparable in all three temperature regimes (ambient, intermittent heating and continual heating). This was the case for the ectoprocts, *Aetea anguina*, *Crisia occidentalis*, *Filicrisia franciscana* and *Scruparia ambigua*; the mollusks, *Chama pellucida*, *Crepipatella lingulata*, *Hiatella arctica*, *Hinnites multirugosus*, *Leptopecten latiauratus*, *Mytilus edulis*, *Ostrea lurida* and *Pododesmus cepio*; and the annelids, *Eupomatus gracilis* and *Serpula vermicularis*. Thermal discharge in the field would, thus, be expected to have less effect on larval colonization by the above species than on the sponge, *Leucosolenia botryoides* and the ectoproct, *Cryptosula pallasiana*, whose settlement was restricted in one or both of the heated regimes during the summer. However, as a result of rapid proliferation of *Leucosolenia* and *Cryptosula* in heated water during the fall and winter, the biomass of both these species in the heated tanks reached or surpassed the ambient tank levels by the beginning of the following spring. Thus, for colonial forms, the consequences of reduced recruitment at elevated temperature during the summer may not be long-lasting if growth in heated water is enhanced relative to the ambient condition during the succeeding colder months.

All the species which settled in the heated tanks have been previously reported from Southern California so none can be considered solely as warm-water immigrants. But the ectoproct, *Amathia distans*, and the sponge *Scypha ciliata*, occurred mainly in the continually heated tank and another sponge, *Leuconia barbata*, with a single exception, was found only in the intermittently heated tank. The population of *Leuconia* may have developed in the intermittently heated tank by chance, but the absence of *Amathia* and *Scypha* from ambient temperature water appears to be due to the preference of their larvae for warmer water.

The settlement of most shallow-water epifaunal invertebrates in Southern California is markedly seasonal, with the majority of species settling during the spring or summer (Coe and Allen, 1937). The settling period of a number of spring and summer settlers has been shown to begin when seawater temperature rises to a critical level (Coe, 1932); the critical temperature for the oyster, *Ostrea lurida*, at La Jolla, is 16°C. This temperature was exceeded in the continually heated tank during the middle of March, but no oysters settled in any of the tanks until May, after ambient temperature had reached 16°C. *Ostrea* larvae were certainly in the water prior to May, as the free-swimming stage of this species lasts 30-40 days (Hopkins, 1937). Early settlement in continually heated water did, however, occur for the ectoproct, _Bugula mollis_, and the barnacle, _Pollicipes polymerus_.

Four species, _Crepipatella lingulata_, _Hiatella arctica_, _Mytilus edulis_ and _Eupomatus gracilis_, had established dense enough populations during spring and summer to allow a meaningful comparison of size data. The growth of all these species was stimulated during the spring and retarded during the summer in heated water, especially in continually heated water, compared to growth under ambient conditions.

During the fall and winter, the growth of the entoproct, _Barentsia discreta_; the ectoproct, _Cryptosula pallasiana_, and the oyster, _Ostrea lurida_, was enhanced in both heated regimes. There was good evidence, on the other hand, that the growth of three species, _Chama pellucida_, _Crepipatella lingulata_ and _Hiatella arctica_, was not accelerated in either heated regime during these two seasons.

In the case of _Mytilus edulis_ (for which the most data were accumulated), growth during fall and winter was virtually the same in continually heated water as in ambient temperature water, but was more rapid in intermittently heated water. Mussels which settled in the tanks at the beginning of the experiment (March) were of approximately equal size in all three temperature regimes by the end of the summer (September) because acceleration of growth in heated water during spring was balanced by stunting in heated water during summer. However, the mussel population in intermittently heated water had the largest median size at the end of the experiment due to most rapid growth in that regime during fall and winter.

The reproductive condition of two species of mollusks, Hiatella arctica and Mytilus edulis, and three species of ectoprocts, Bugula mollis, Crisia occidentalis and Filicrisia franciscana, was assessed periodically to ascertain whether sexual maturity (onset of gametogenesis) was reached earlier in heated water than at ambient temperature. Bugula was reproductively active earliest in the continually heated tank by virtue of settling in that tank six weeks prior to settling in any other tank. Crisia and Filicrisia settled in all the tanks at the start of the experiment. However, because ovicell formation was not a function of the size of the colony but of its age, and because reproduction began during the spring (when growth was most rapid in continually heated water), Crisia and Filicrisia also began reproducing earliest in the continually heated tank. Hiatella and Mytilus, like Crisia and Filicrisia, settled at the beginning of the experiment in all three temperature regimes, and size at maturity in each regime was equivalent. Hiatella began reproducing in the spring, and individuals matured earliest in the continually heated tank due to fastest growth in that regime. The specimens of Mytilus which initially colonized the tanks began reproducing at approximately the same time of year in all three temperature regimes because gametogenesis was initiated at the end of the summer, a time when the largest Mytilus in all the tanks were of comparable size.

It seems reasonable to assume then when reproduction is initiated earlier in heated water than normal, earlier spawning will also occur. Since currents transport mero-plaktonic larvae away from the area where they are generated, larvae produced by members of the fouling community in the thermal field around a power plant outfall are soon swept into ambient temperature water. Consequently, early reproduction in heated water of species with distinct settling seasons, such as Bugula, Crisia and Filicrisia, would result in their larvae being swept into the ambient environment prior to the time they are naturally placed in the water column and when hydrological conditions may be suboptimal for their survival. This is an example of the possible adverse consequences of a sublethal temperature effect; the spawning of epifauna inhabiting the area adjacent to a thermal discharge might be entirely unsuccessful if the timing of their reproductive cycle were advanced in heated water.

The survival of Aetea anguina, Chama pellucida, Mytilus edulis, Ostrea lurida and Eupomatus gracilis, was comparable in all three temperature regimes. For the ectoprocts, Bugula mollis, Crisia occidentalis, Filicrisia franciscana and Scruparia ambigua, the annual cycle of settlement, colony growth, reproduction and colony deterioration was completed earliest in continually heated water. There was little, if any, advancement of this cycle in intermittently heated water compared to the ambient condition.

The 3°C temperature elevation was selected to study sublethal effects, however, unusually high ambient temperatures during the month of August were probably directly responsible for the considerably lower survival of Hiatella arctica in continually heated water compared to other regimes. Continual heating during the summer was even more devastating for the mollusks, Hinnites multirugosus, Leptopecten latiauratus and Pododesmus cepio, and for the annelid, Serpula vermicularis. These species settled in all three temperature regimes during the spring, but survived through the summer only in intermittently heated water and in ambient temperature water. Thus, it appears that the periodic exposure to ambient temperature in the HA regime mitigated the severity of the impact of artificially elevated temperature during the summer.

In most cases, the response of a species to increased temperature could not have been predicted from either its published thermal tolerance or known geographical distribution. Mytilus edulis was the only species whose response could be compared to a previously measured upper lethal temperature. Even for fishes, which have been the subject of numerous thermal studies, specific thermal information exists for less than 5% of the species of the United States and Canada (Mihursky and Kennedy, 1967). Attempts to correlate the geographical range of those species having relatively well-known distributions with their reaction to experimentally elevated temperature were generally unsuccessful. For example, the disappearance of Pododesmus, Hinnites and Leptopecten from the continually heated tank during the summer might have been anticipated if these species, at La Jolla, are living closer to the southern limit of their Eastern Pacific range than Chama and Ostrea, whose survival was unaffected at elevated temperature. But the reported southern boundary for all five of these bivalves is practically identical (McLean, 1969); none range south of Baja California. Of the three species of sponges which occured in the experimental seawater system, Scypha ciliata settled mainly in continually heated water, Leuconia barbata primarily settled in intermittently heated water, and Leucosolenia botryoides colonized all three regimes. This thermal selectivity was unexpected, since all three sponges have cosmopolitan distributions (Burton, 1963).

The epifauna which colonized the experimental seawater system exhibited a variety of responses to elevated temperature, ranging from enhancement to restriction of settlement, growth and survival, with some species being unaffected in heated water. These results are contrary to the frequent assumption that epibenthic invertebrates have a characteristic response to high temperatures.

For a given species in the fouling community, the effect of increased temperature usually varied with the season; there was most evidence of thermal stress in continually heated water during the summer. Virtually all the species present in both heated regimes throughout the summer were substantially less affected in intermittently heated, than in continually heated, water.

Species Diversity

The species diversity in each quadrat examined on the plates in the long-term series of sets was expressed in two ways: the number of species present, and the Shannon-Wiener index. Summary statistics for these two measures of species diversity are given in Table 41; as with previous tables, asterisks indicate significant differences.

Although species diversity considerations usually involve a single taxonomic group (MacArthur, 1965), the diversity of the entire assemblage of invertebrates counted on the plates (Table 1) was computed. This was done to elucidate gross differences in the structure of communities which developed in the three temperature regimes. More restrictive diversity comparisons, considering phyla or classes individually, will be performed at a later date.

Reish (1964) reports that the number of species in the community associated with *Mytilus edulis* on docks in a Los Angeles harbor was positively correlated with water temperature. More species were found during the summer than in the winter. The number of species in this study was also greatest during the summer (Fig. 20), although diversity in terms of the Shannon-Wiener index appears to have peaked earlier in the year (Fig. 21).

The low Shannon-Wiener index for the HA plate in Set 3 is due to a preponderance of copepods on that plate (Table 37). If copepods are excluded from the diversity calculations for Set 3, the significance of the difference between the Shannon-Wiener index for the HA plate and the A2 plate (Table 41) disappears.

The largest difference in the median number of species per quadrat between plates from heated and ambient water occurred in Set 6 (Fig. 20). The more disparate Shannon-Wiener values for Set 6 (Fig. 21) reflect a less equitable distribution of individuals among species on the HA and HH plates than on the ambient plates, as well as a lower absolute number of species. After the summer, the diversity of the community in the intermittently heated tank appears to have rapidly returned to a level comparable to the communities in the ambient tanks. However, only partial recovery is indicated in continually heated water, as the HH tank Shannon-Wiener species diversity was the lowest at 9 and 12 months, and there was a considerable difference in diversity between the communities on the ambient plates and the HH plate in Set 12.

These results suggest that epifaunal diversity in the area around a Southern California coastal power plant heated in excess of 3°C may be depressed during the warmest summer months relative to the condition at ambient temperature. Epifaunal communities in that area of the thermal field which is continually heated 3°C or more above ambient temperature may be permanently impoverished compared to the situation in intermittently heated, or ambient temperature water.

The significant reduction in the species diversity of the fouling community in the heated tanks during the summer compared to the ambient tanks is consistent with the previously cited results of Nauman and Cory (1969) and Pearce and Young (Studies on the Effects of a Steam-Electric Generating Plant on the Marine Environment at Northport, New York, 1971). Warriner and Brehmer (1966) studied the benthic infauna near a power plant on the York River Estuary in Virginia. They also found that diversity was substantially less in heated water during the summer than at control stations. In all three of these studies, conducted on the northeast coast of the United States, species diversity during the colder seasons was greater in heated water than at ambient temperature. In my study at La Jolla there was no evidence of enhanced diversity in the heated tanks during the colder months.

LIMITATIONS TO GENERALIZATION OF THE RESULTS

1. The laboratory conditions of my research differed in a number of important respects from the natural environment. The exclusion of light from the experimental aquaria precluded development of a floral component of the fouling community. Also, large predators, such as fish and seastars, were inexplicably absent, although it should have been possible for their larvae to colonize the tanks. Nevertheless, the *Mytilus*-dominated fouling community which had developed in the ambient tanks by the end of the experiment was remarkably similar to the comparable successional stage of this epifaunal community in the field.

2. The experiment covered a year's time. But it takes more than a year, probably two or three years (Coe and Allen, 1937), for the *Mytilus* community to reach a climax state. The trends suggested by the results would have been most conclusively established if the experiment had been extended until a climax community had formed.

3. Since only a single temperature rise above ambient (3°C) was studied, direct extrapolation from my results to the consequences of higher or lower thermal elevations would be incautious and unwarranted. The

propriety of suggesting what might have occurred if the seasons during the experiment had been warmer or colder or if the intermittently heated regime had involved unequal, alternating intervals is questionable, as well.

4. Finally, and perhaps most importantly, the usefulness of the results of this experiment for predicting the consequences of power plant discharge on the development of epifaunal communities is dependent on the validity of the usual assumption that, of all the water quality parameters altered by the discharge of power plant cooling-water (temperature, currents, light, oxygen content, chlorine, etc.), elevation of seawater temperature will have by far the greatest effect on the marine biota. Unfortunately, the validity of this assumption has yet to be tested. The extent to which alterations in each parameter, or combination or parameters, associated with the discharge of cooling-water are correlated with changes in aquatic biota in the receiving waters could be determined by multiple regression of appropriate physical and chemical variables against biological data. However, a sampling program to measure the full spectrum of variables necessary for such a multivariate analysis has yet to be carried out at any power plant.

Notwithstanding these restrictions, this research indicates that relatively low temperature elevations produced by thermal discharge from coastal power plants may significantly alter the settlement and development of epifaunal communities. Intermittently increased temperature would be expected to have much less effect than continually increased temperature.

SUMMARY AND CONCLUSIONS

Two thermal regimes created by the discharge of power plant effluent into tidal waters were simulated in experimental aquaria under controlled environmental conditions in order to isolate and study the influence of increased temperature on the development of a marine community. The objective of this research was to determine the effects of elevated temperature, characteristic of the thermal field around a coastal power plant outfall, on the settlement, growth, reproduction and survival of epifaunal invertebrates with meroplanktonic larvae. More than 100 macroscopic species of invertebrates settled in the experimental seawater system. Twenty-two species were sufficiently abundant to provide an indication of their response to the three temperature regimes: 1) continually increased temperature, 3°C above ambient, 2) intermittently increased temperature, alternating six-hour periods of ambient temperature and 3°C above ambient and 3) ambient temperature, the control environment.

In the following categorization of responses, the species are ordered taxonomically, as in Table 1.

Settlement

Settlement comparable in all three temperature regimes:

Crisia occidentalis
Filicrisia franciscana
Aetea anguina
Scruparia ambigua

Crepipatella lingulata
Chama pellucida
Hiatella arctica
Hinnites multirugosus
Leptopecten latiauratus
Mytilus edulis
Ostrea lurida
Pododesmus cepio
Eupomatus gracilis
Serpula vermicularis

Settlement earliest in continually heated water during spring:

at approximately the same time in intermittently heated and ambient temperature water:

Bugula mollis

last in ambient temperature water:

Pollicipes polymerus

Settlement restricted during summer:

in both heated regimes:

Leucosolenia botryoides

only in continually heated water:

Cryptosula pallasiana

Settlement mainly in intermittently heated water:

Scypha ciliata

Settlement mainly in continually heated water:

Leuconia barbata
Amathia distans

Growth

Growth accelerated in both heated regimes, especially in continually heated water, during spring:

Crisia occidentalis
Filicrisia franciscana

Hiatella arctica
Mytilus edulis
Eupomatus gracilis

Growth retarded in both heated regimes, especially in continually heated water, during summer:

Crisia occidentalis
Filicrisia franciscana
Mytilus edulis
Eupomatus gracilis

Growth comparable in all three temperature regimes during fall and winter:

Crepipatella lingulata
Chama pellucida
Hiatella arctica

Growth accelerated during fall and winter:

in both heated regimes:

Cryptosula pallasiana
Barentsia discreta
Ostrea lurida

only in intermittently heated water:

Mytilus edulis
Eupomatus gracilis

Reproduction

Reproduction initiated at approximately the same time in all three temperature regimes:

Mytilus edulis

Reproduction initiated earliest in continually heated water:

Crisia occidentalis
Filicrisia franciscana
Bugula mollis
Hiatella arctica

Survival

Survival comparable in all three temperature regimes:

Aetea anguina
Chama pellucida
Mytilus edulis
Ostrea lurida
Eupomatus gracilis

Colony deterioration earliest in continually heated water:

Crisia occidentalis
Filicrisia franciscana
Bugula mollis

Survival reduced in continually heated water during summer, but not comparable in intermittently heated and ambient temperature water:

Hiatella arctica
Hinnites multirugosus
Leptopecten latiauratus
Pododesmus cepio
Serpula vermicularis

This variety of responses exhibited by species which colonized the experimental seawater system demonstrates that epibenthic invertebrates, as a group, do not have a typical response to elevated temperature. The results had one common feature, however: a continuous 3°C elevation above ambient temperature definitely altered the settlement, growth, reproduction and survival of the epifauna to a far greater extent than intermittently increased temperature.

The development of the epifaunal communities in the three temperature regimes was equivalent during the spring, but by the end of the summer the species diversity in both heated tanks was significantly lower than in the ambient tanks. Community diversity in intermittently heated water returned to a level comparable to that of the ambient communities during the succeeding fall, while diversity in continually heated water had not recovered to the ambient level by the end of the year-long experiment.

This research suggests that power plant-induced thermal elevation of the marine environment may significantly affect the establishment of epifaunal communities in the area surrounding the outfall which is continually heated. Substantially less effect would be predicted where thermal addition is intermittent, that is, in areas alternately exposed to ambient temperature and elevated temperature as a result of tidal diversion of discharged thermal effluent.

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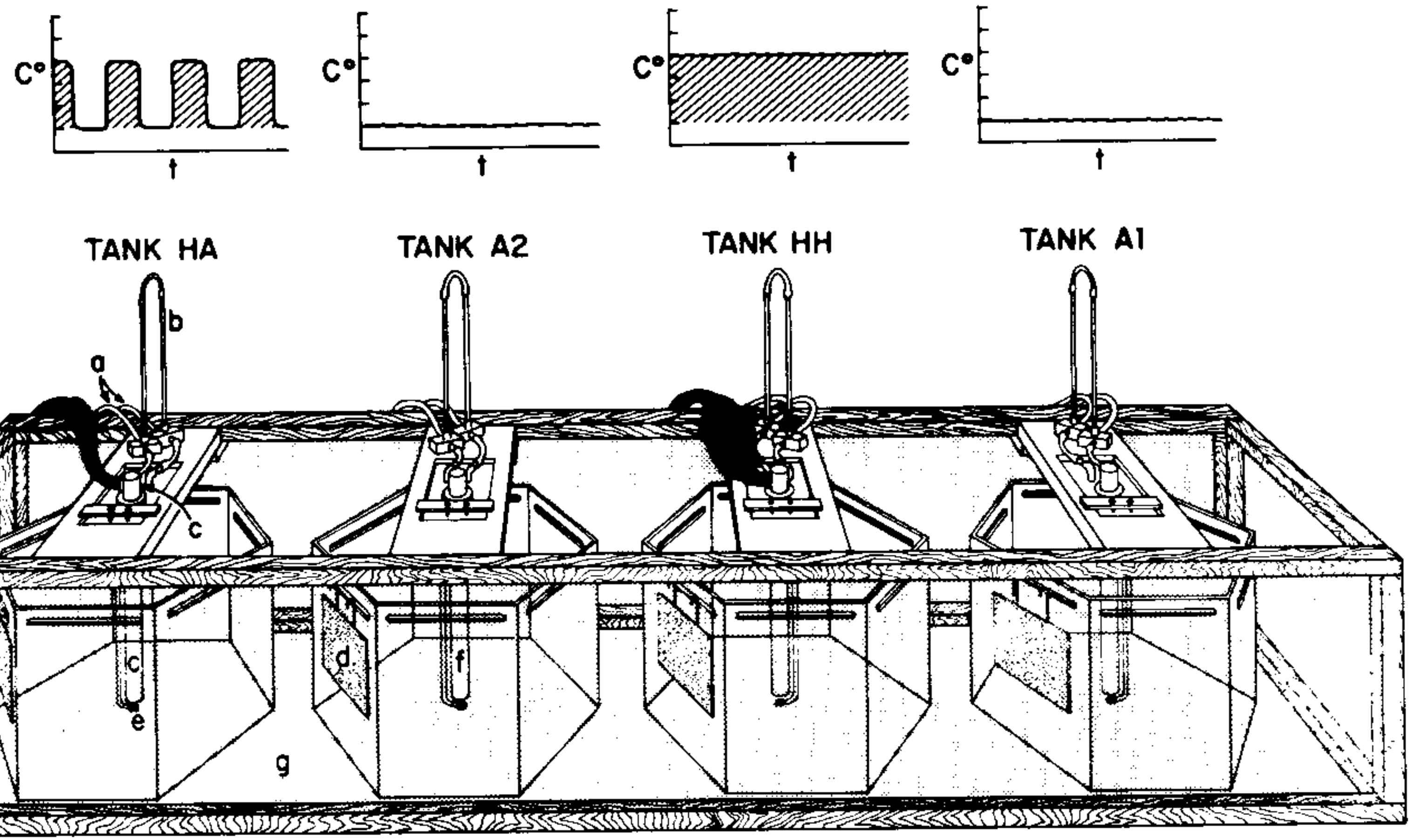
Figure 1. Experimental sea water system (schematic). The volume of each tank is 45 gallons; settling plates are 30 cm by 30 cm. Tank positions were chosen at random. The graph above each tank portrays the temperature regime.



a - Sea Water supply
b - Sea water flow meters
c - Immersion heater
d - Settling plate
e - Airstone
f - Dummy heaters
g - Sea table
h - Sea water drain

Figure 2. An example of the temperature record from the ambient, intermittently heated and continually heated tanks. The lower, solid line is the ambient trace; the upper, solid line is the trace from the continually heated tank. The dotted line indicates the temperature pattern in the intermittently heated tank.

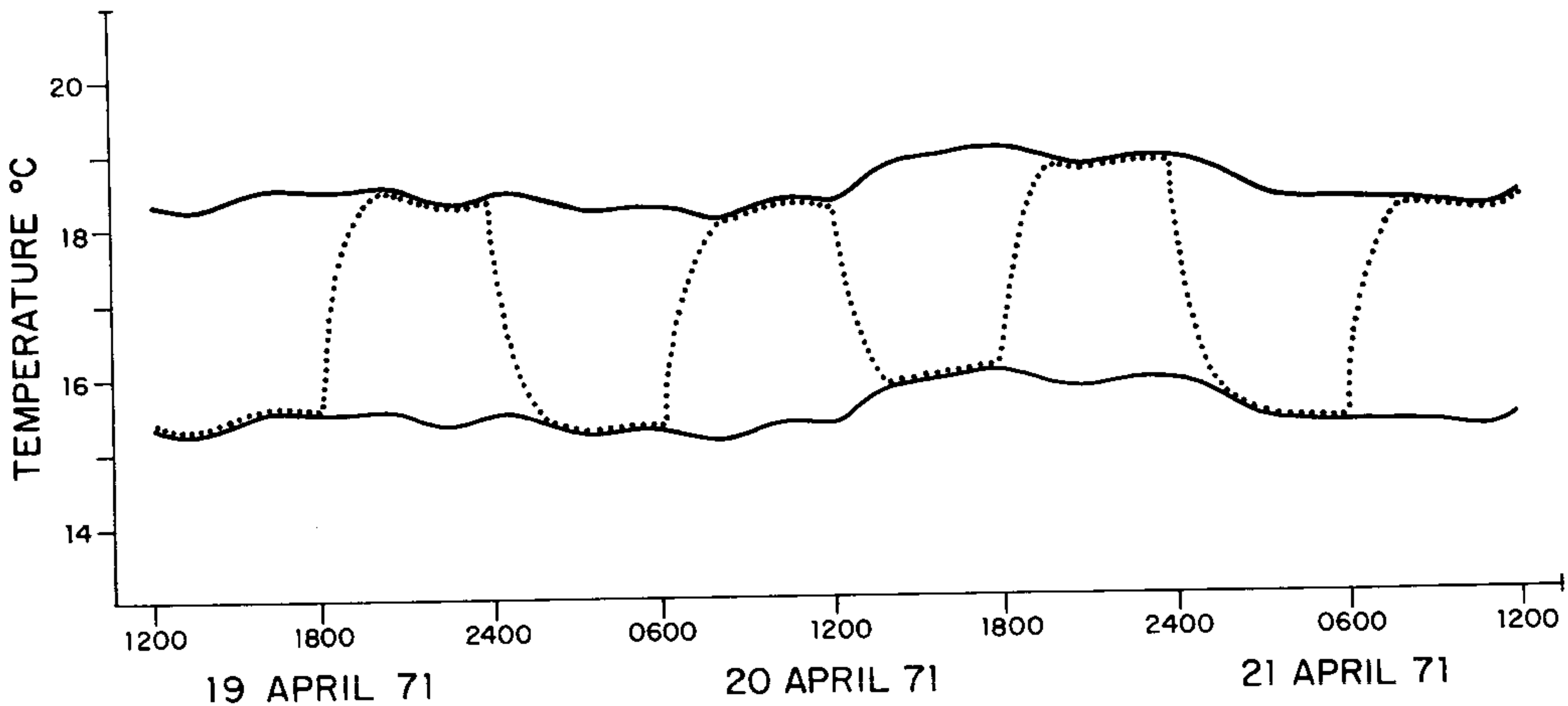


Figure 3. Effect of tidal currents on dispersion of thermal effluent from a coastal power plant. The small straight arrows indicate tidally-induced current direction. The power plant outfall would be at the center of the solid circles; the stippled area represents the thermal plume streaming away from the outfall. Note that the thermal plume rotates around the outfall twice daily. Only the area within the solid circles would be continually heated. An organism at point X would be alternately subjected to heated water and ambient temperature water. (Current data confirming this pattern at the San Onofre, California, nuclear power plant will soon be released [L. Adamo, Intersea Research Corporation, personal communication]).

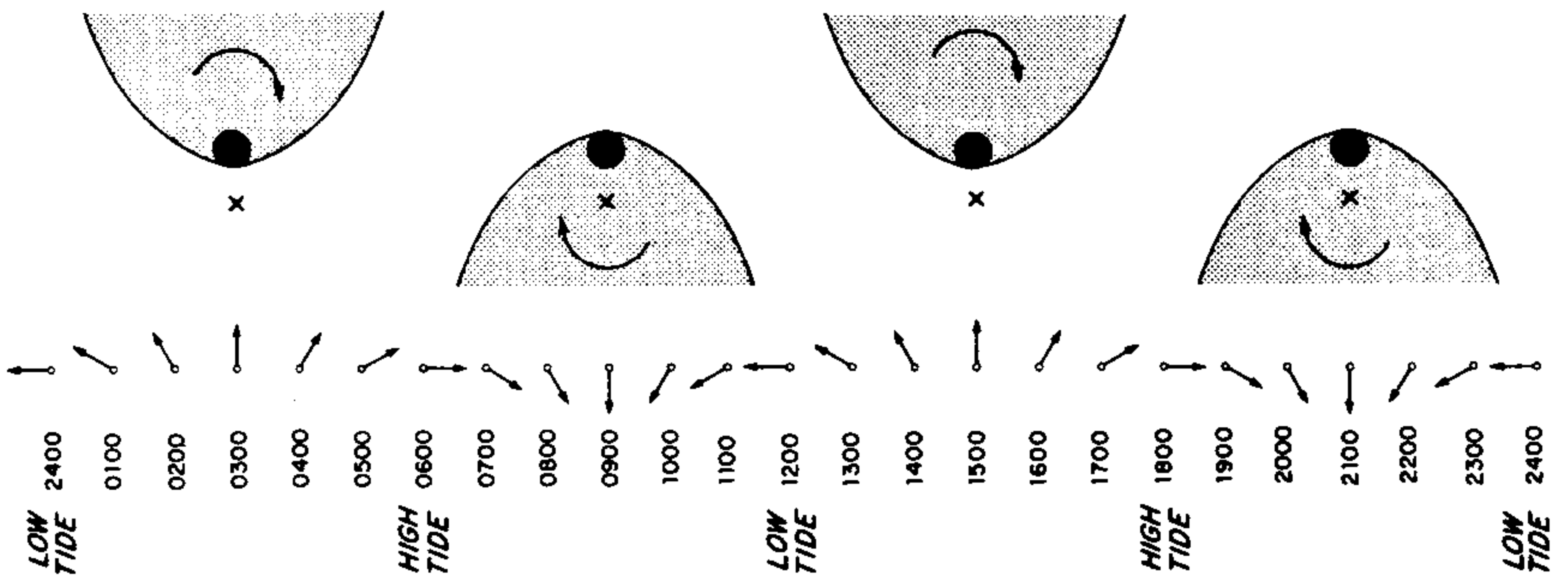


Figure 4. Period of exposure for sets of settling plates. Set is abbreviated by the capital letter S.

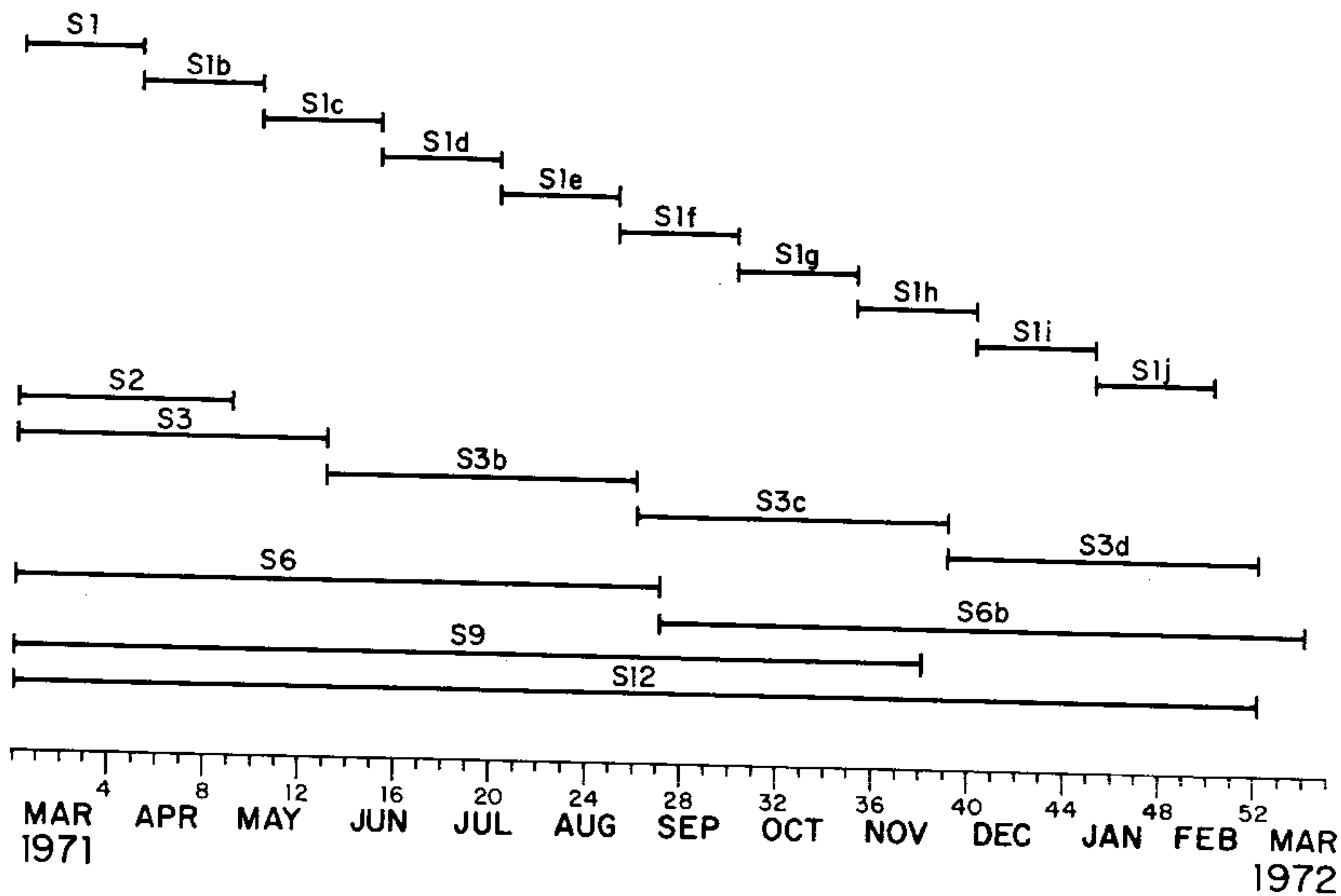


Figure 5. Quadrat subsampling procedure. Subsamples of five quadrats were selected by choosing randomly between quadrats 1 and 7, 2 and 8, 3 and 9, 4 and 6, and always including quadrat 5. An example of subsamples generated in this fashion is shown below. Six-quadrat samples consisted of quadrats 2, 5 and 8, and either 1 or 3, 4 or 6, 7 or 9.

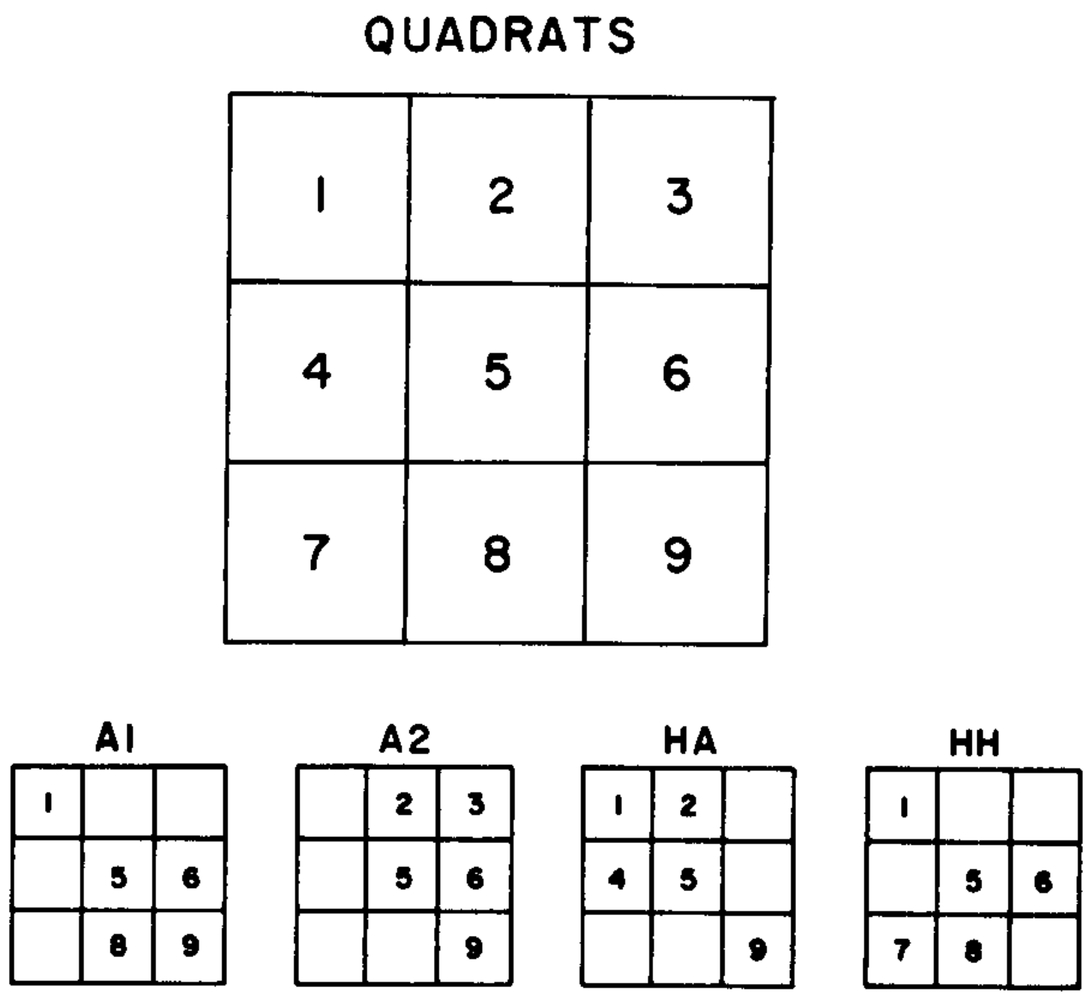


Figure 6 Sea water temperature in the experimental system. Weekly mean ambient temperatures are plotted over the period of the experiment, 1 March 1971 to 13 March 1972.

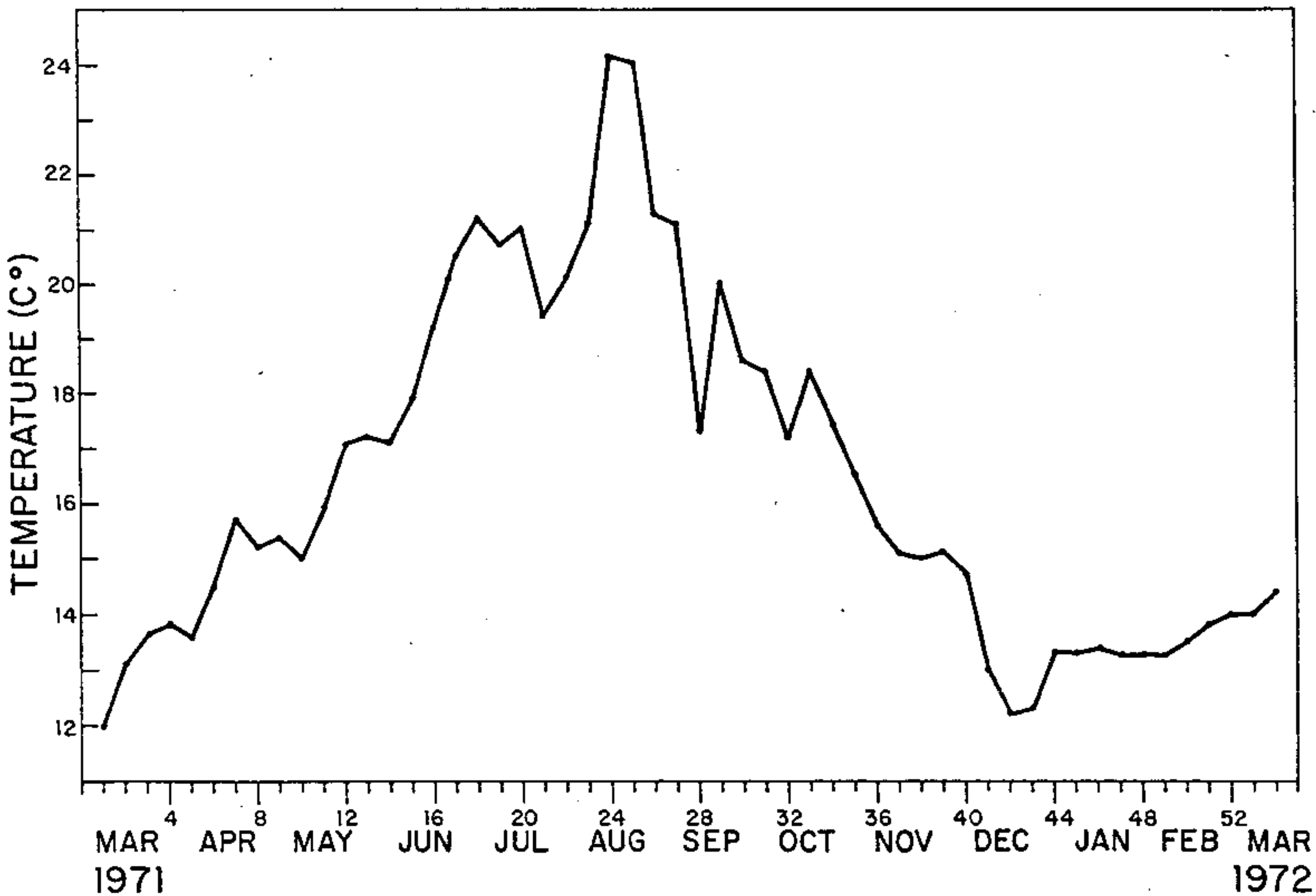


Figure 7. Temperatures prevailing during periods of exposure for sets of settling plates.

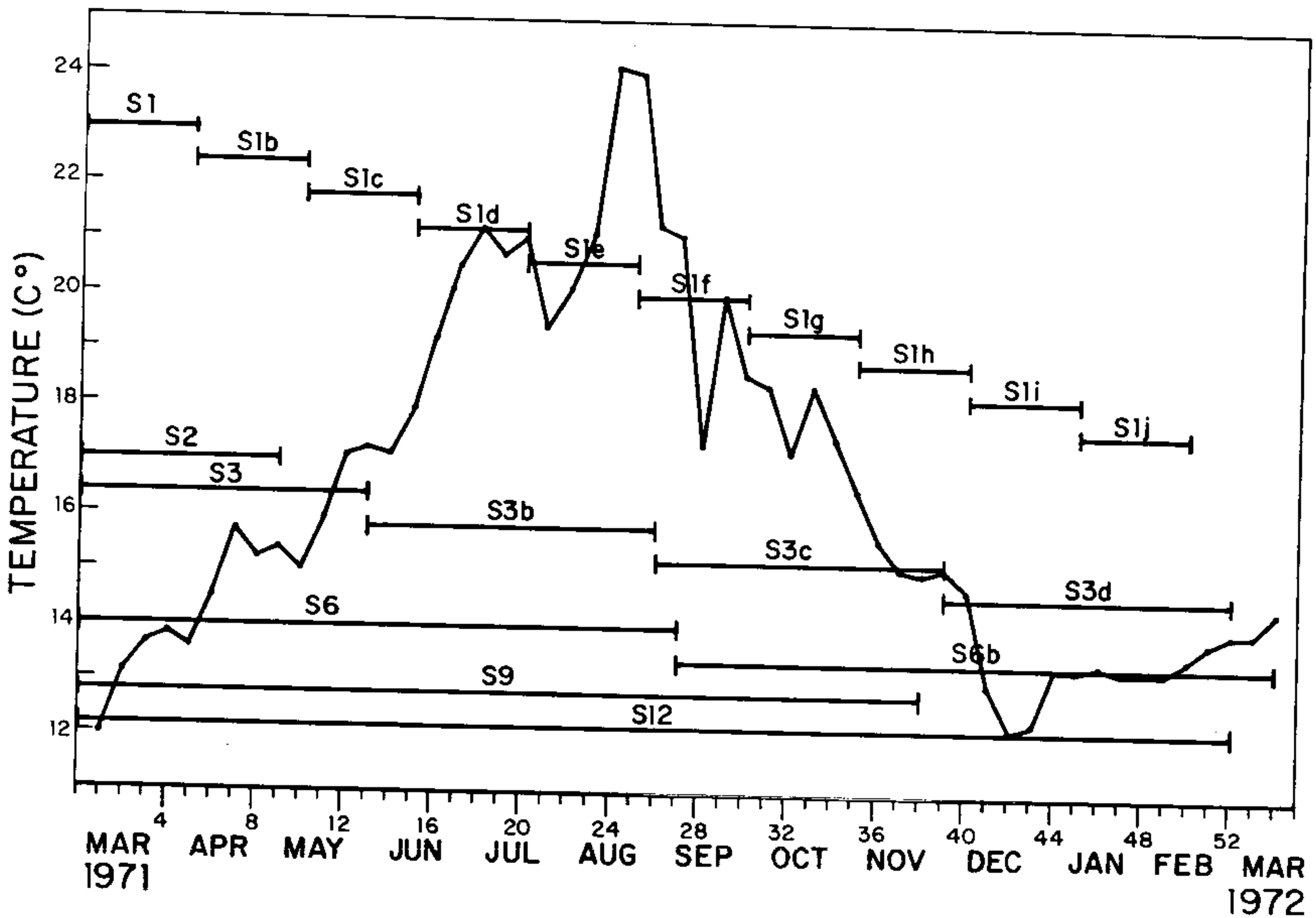


Figure 8. Sea water temperature in the experimental system compared to the 50-year mean at Scripps. Monthly mean temperatures are plotted.

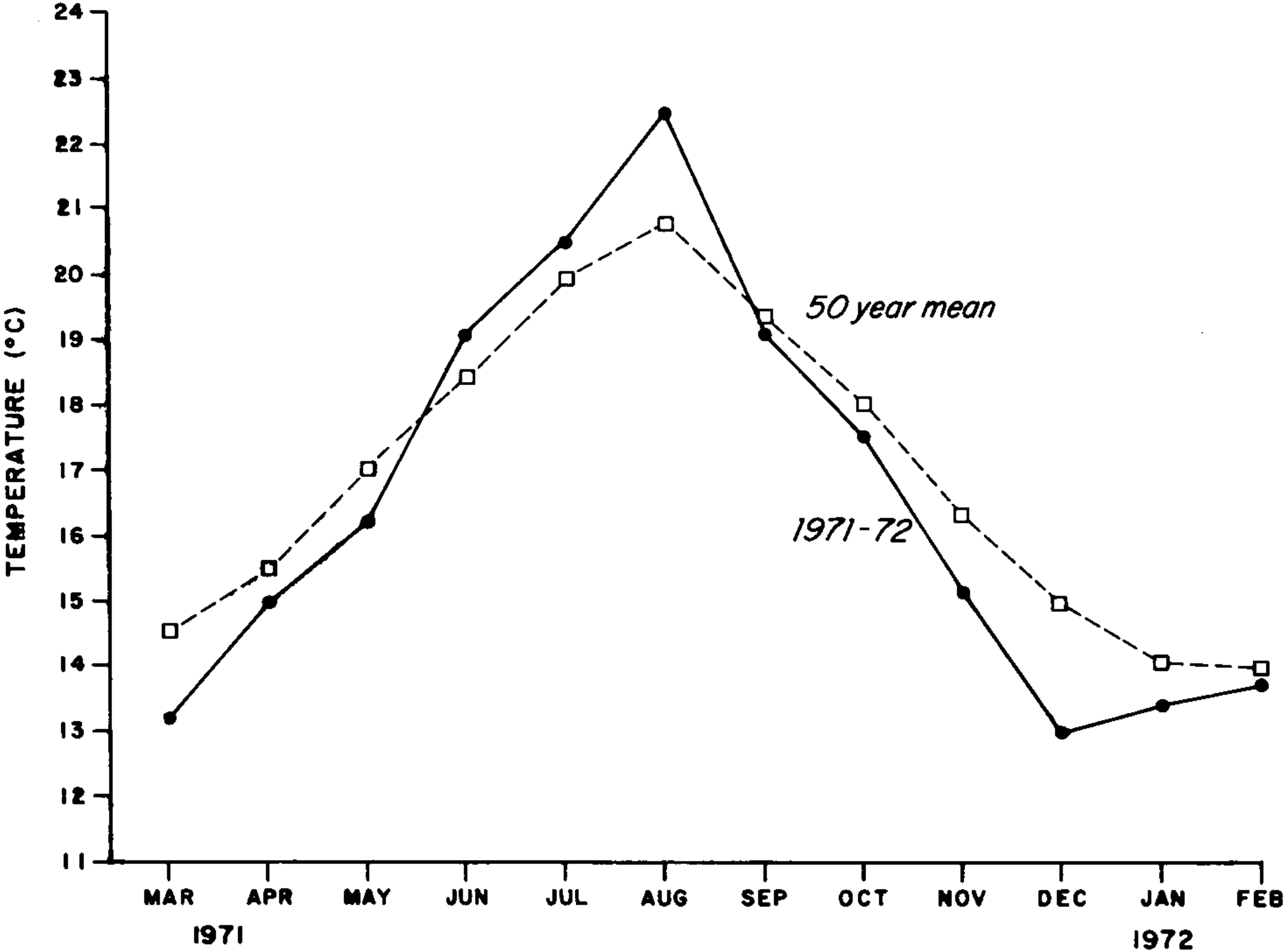


Figure 9. Biomass indices for Leucosolenia botryoides.

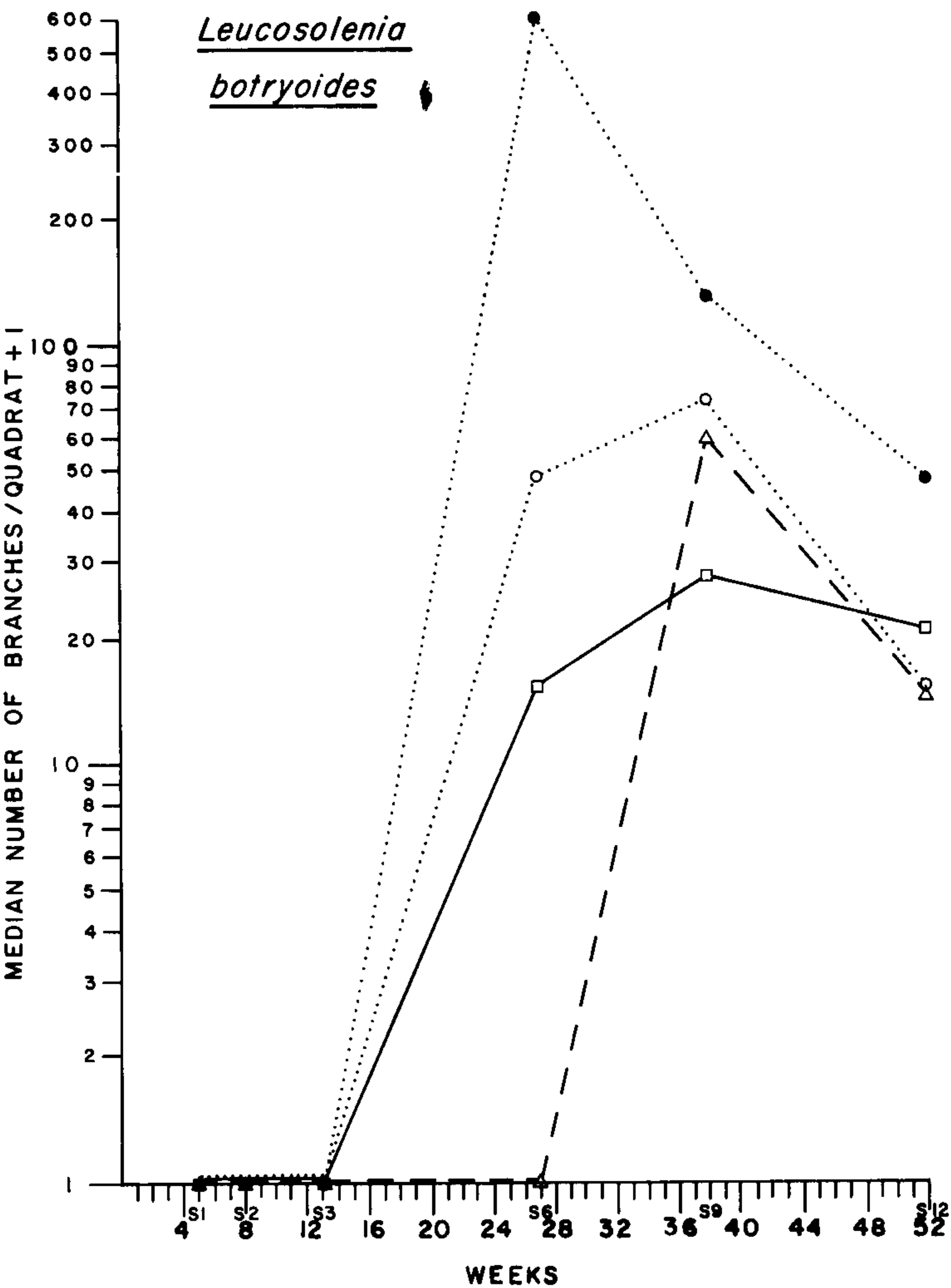


Figure 10. Zooid density indices for Crisia occidentalis.

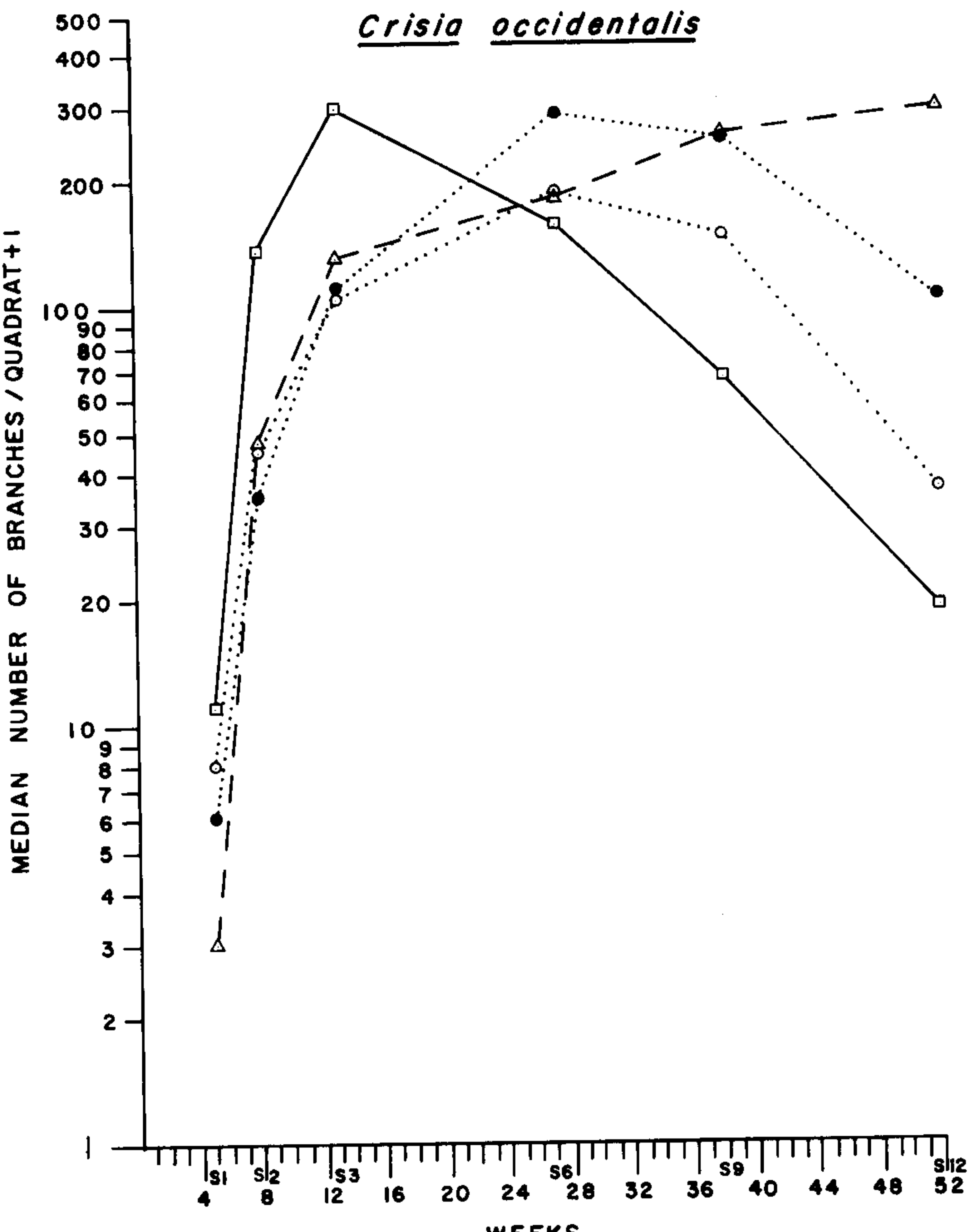


Figure 11. Zooid density indices for Filicrisia franciscana.

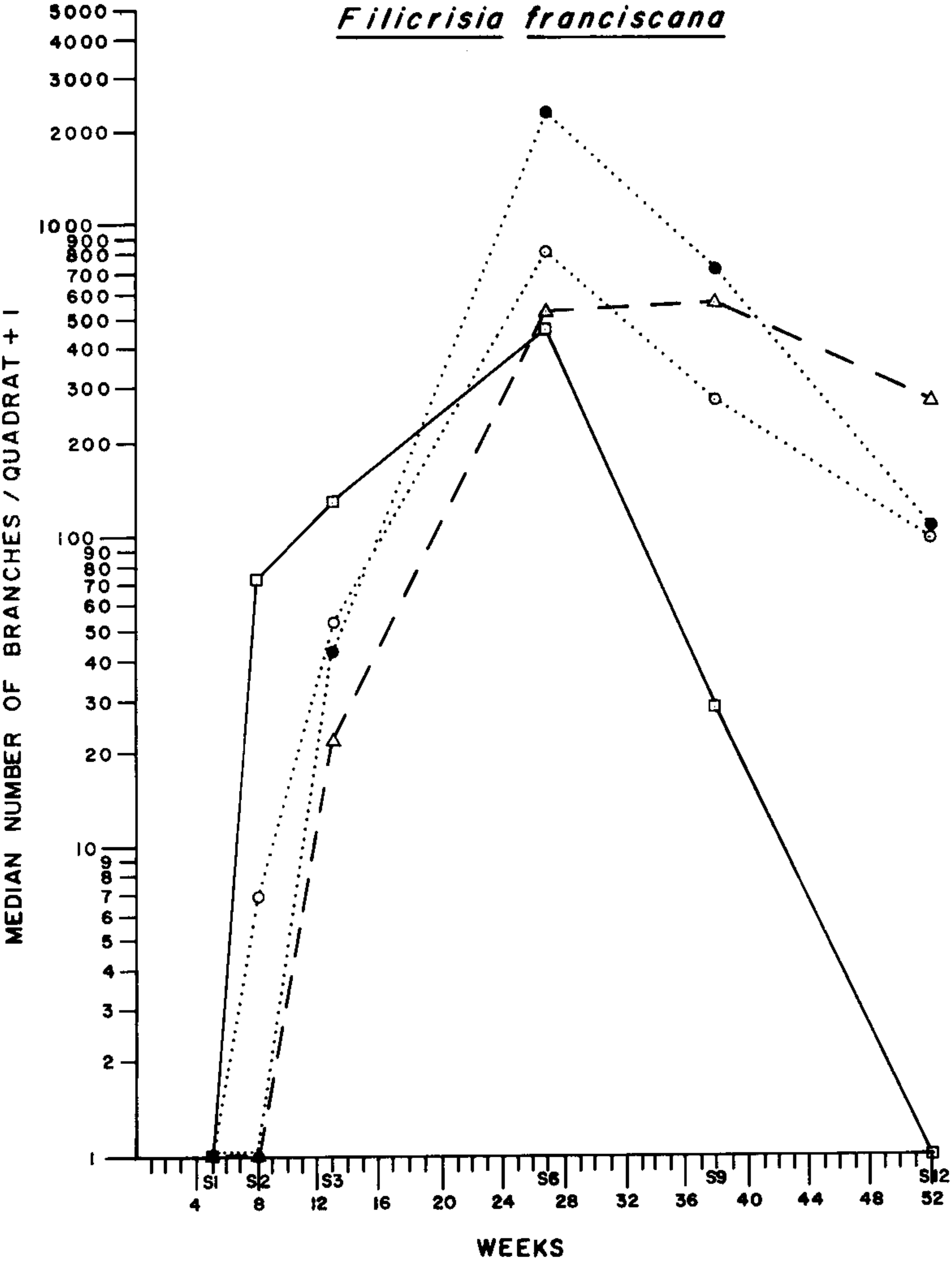


Figure 12. Zooid density indices for Amathia distans.

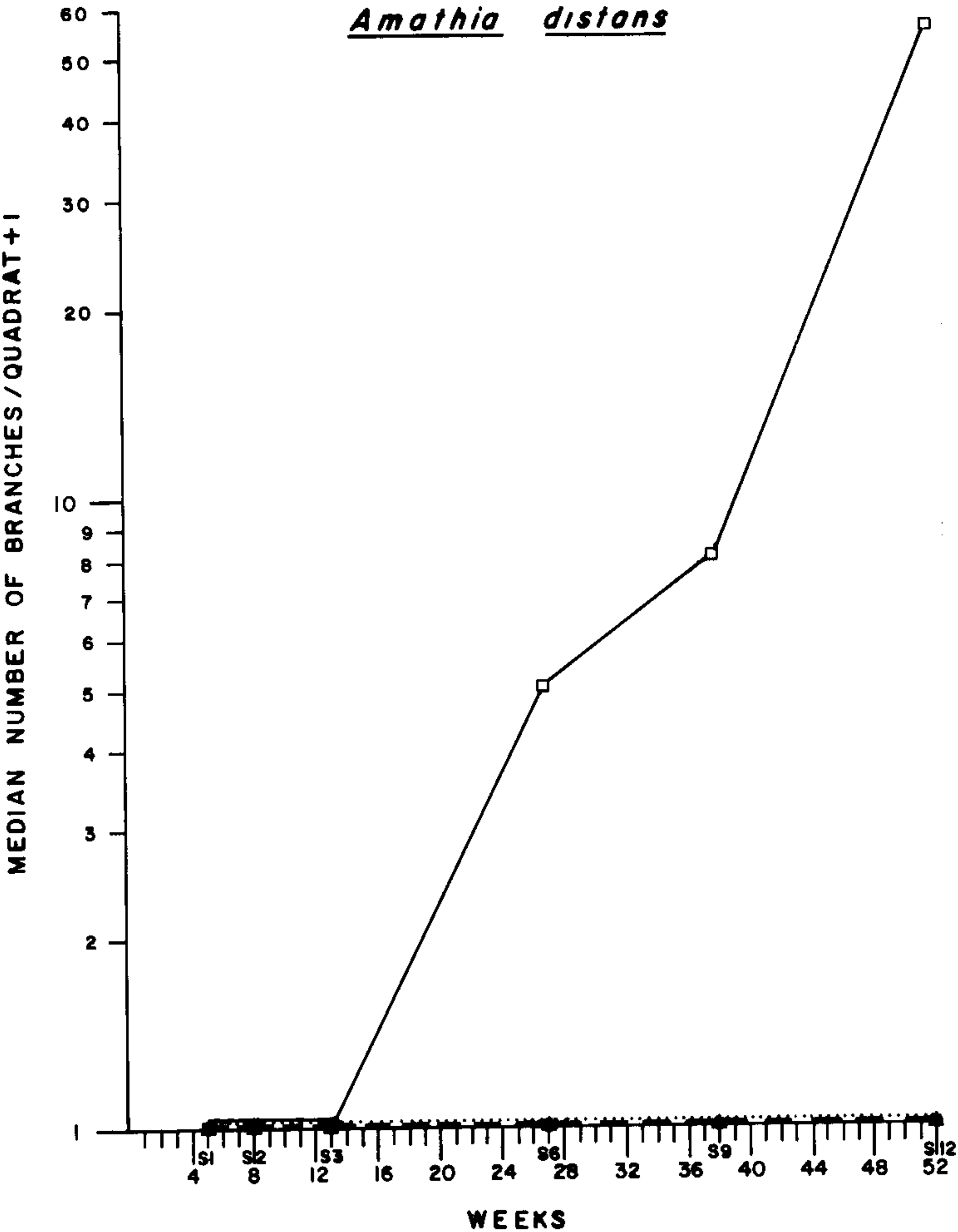


Figure 13. Zooid density indices for <u>Bugula</u> <u>mollis</u>.

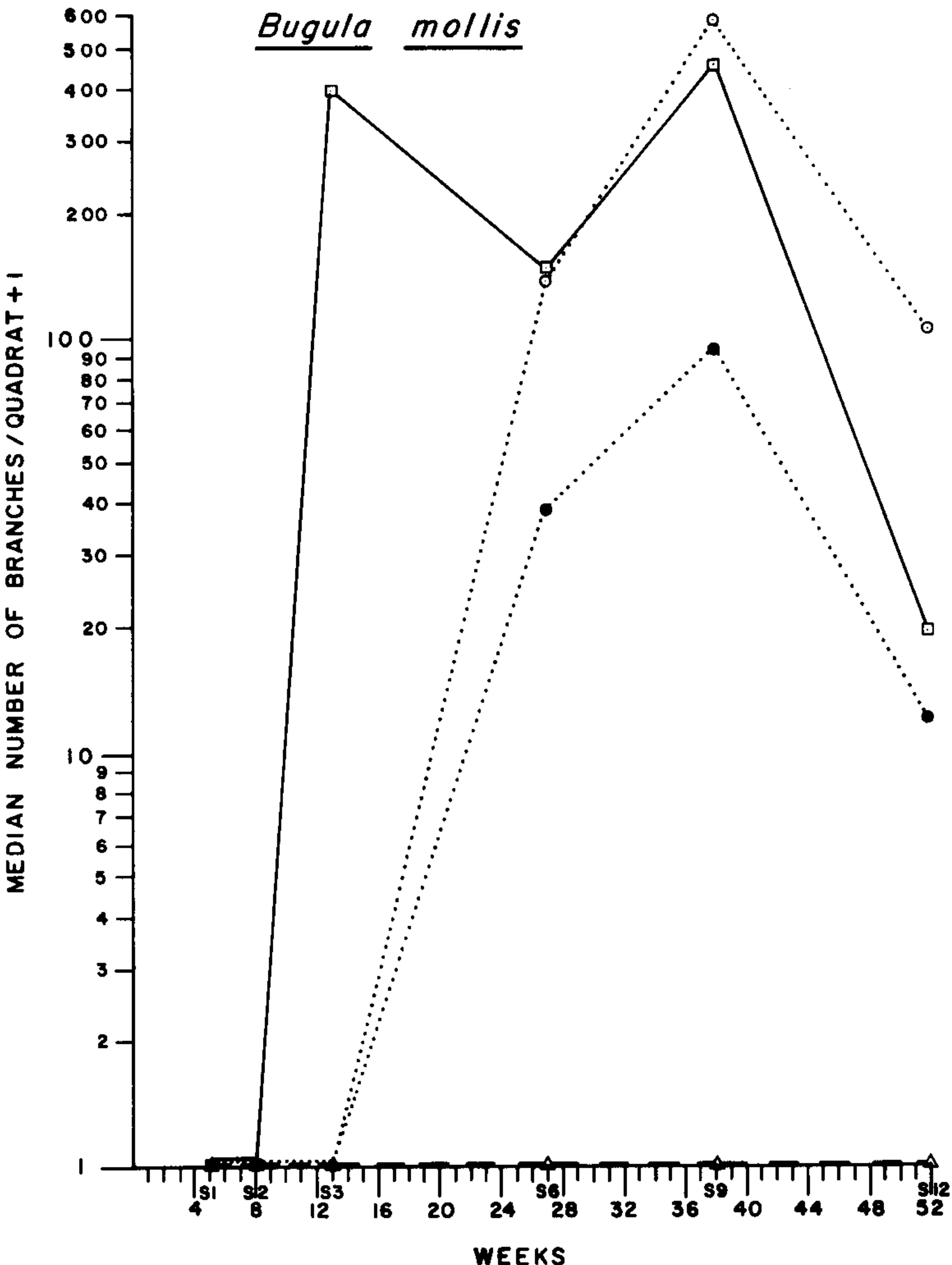


Figure 14. Zooid density indices for Scruparia ambiqua.

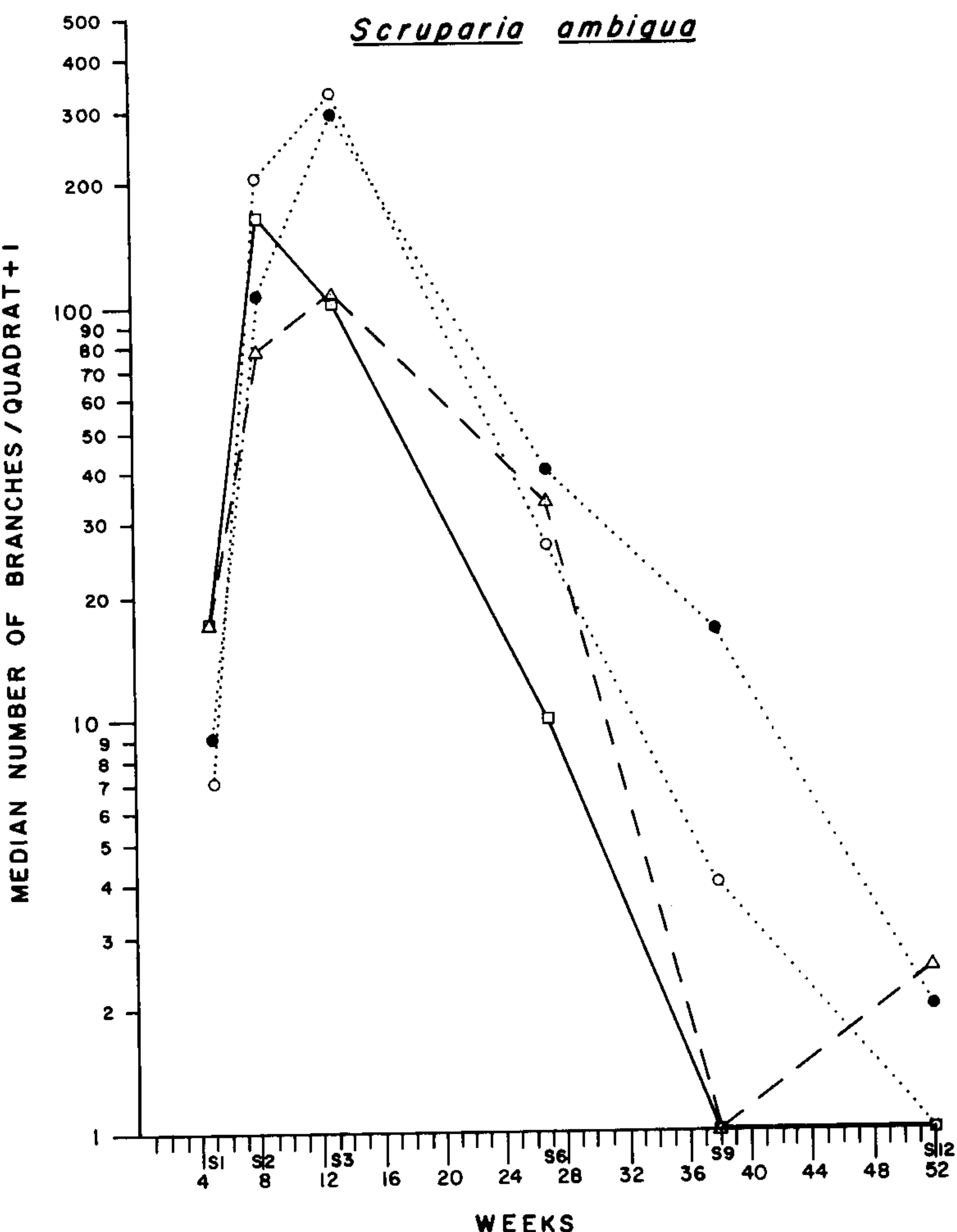


Figure 15. Size-frequency histograms for <u>Crepipatella lingulata</u>

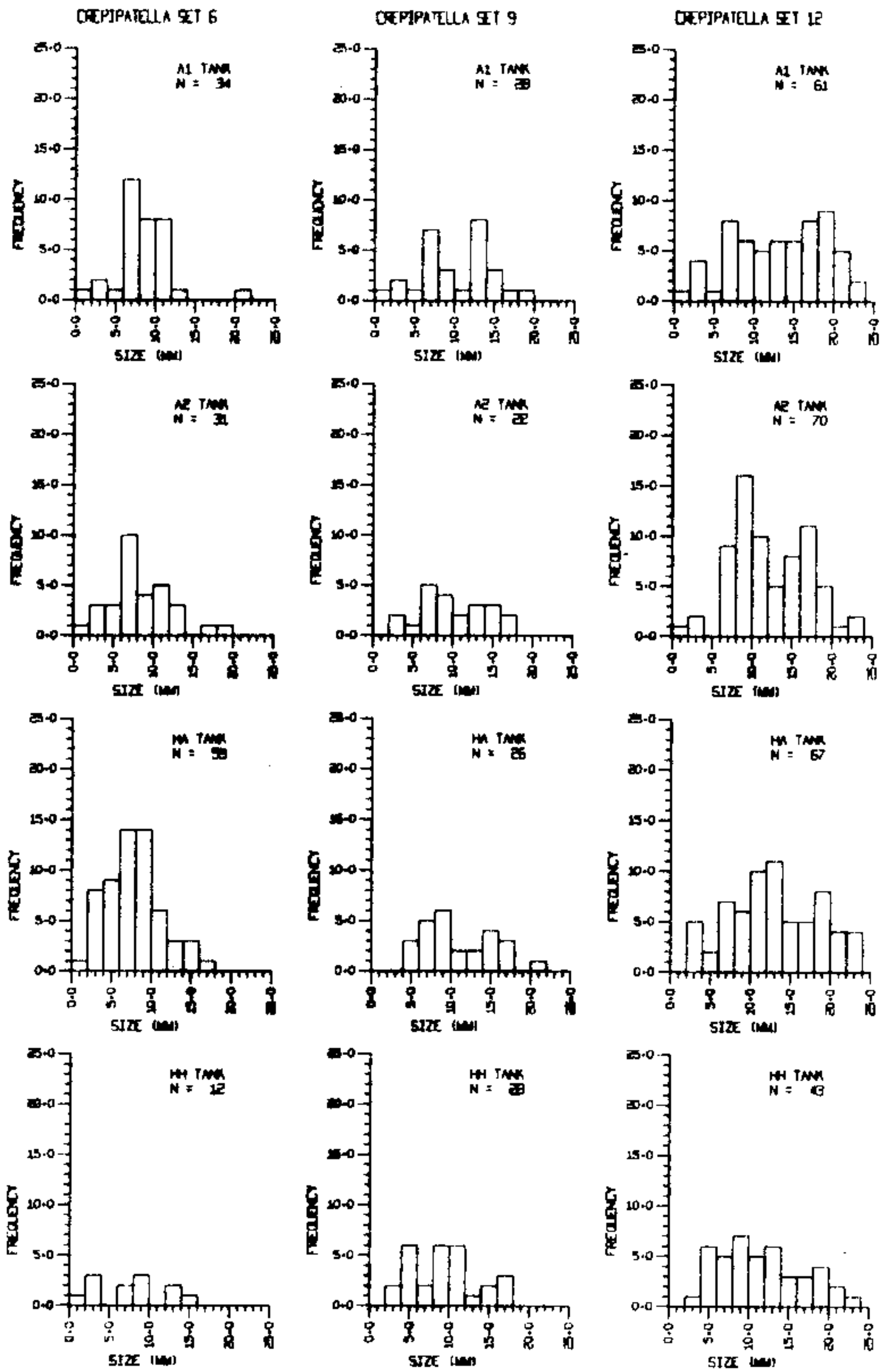


Figure 16. Size-frequency histograms for <u>Hiatella</u> <u>arctica</u>.
(Continued on the following page.)

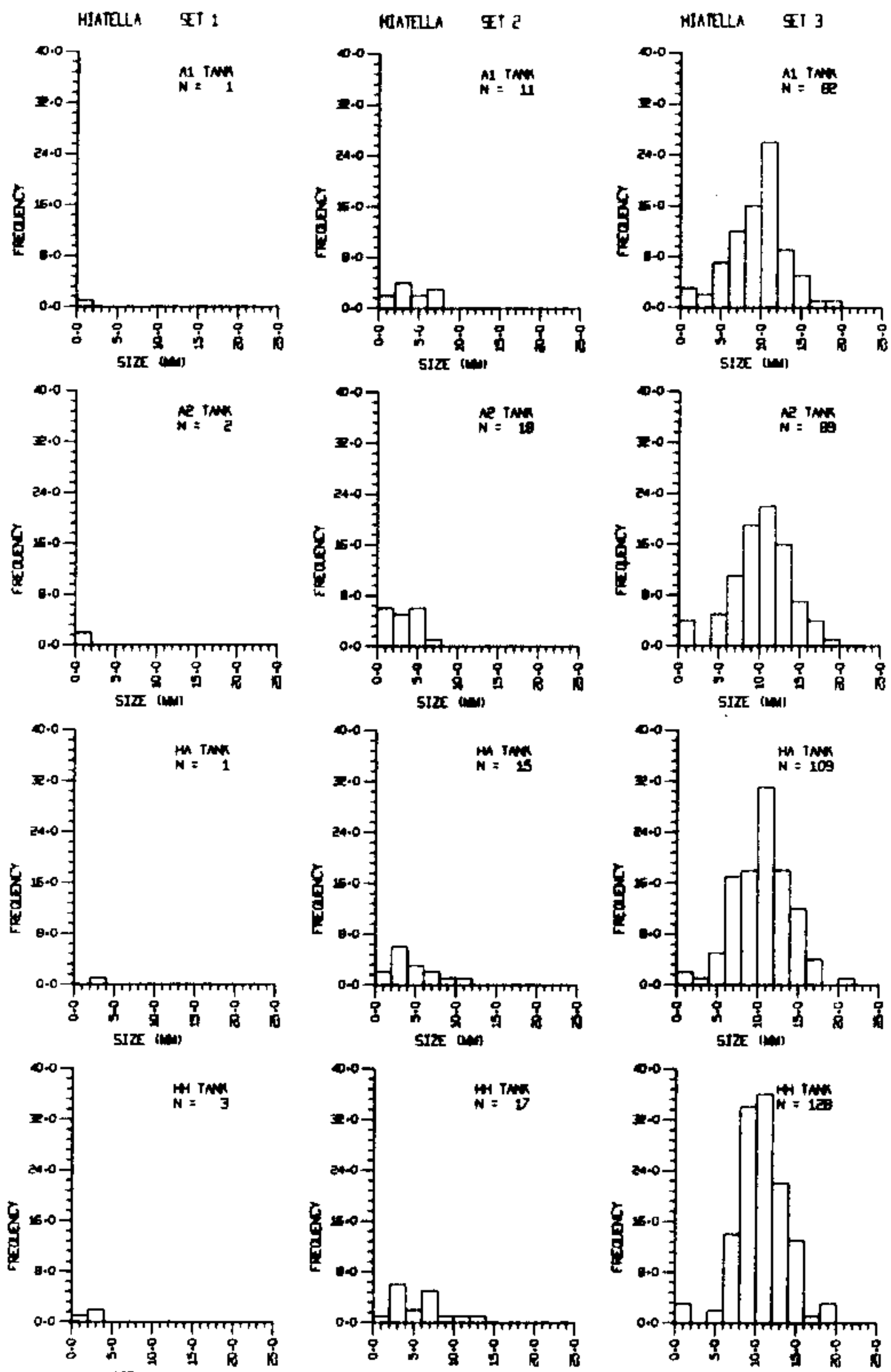


Figure 16. Continued.

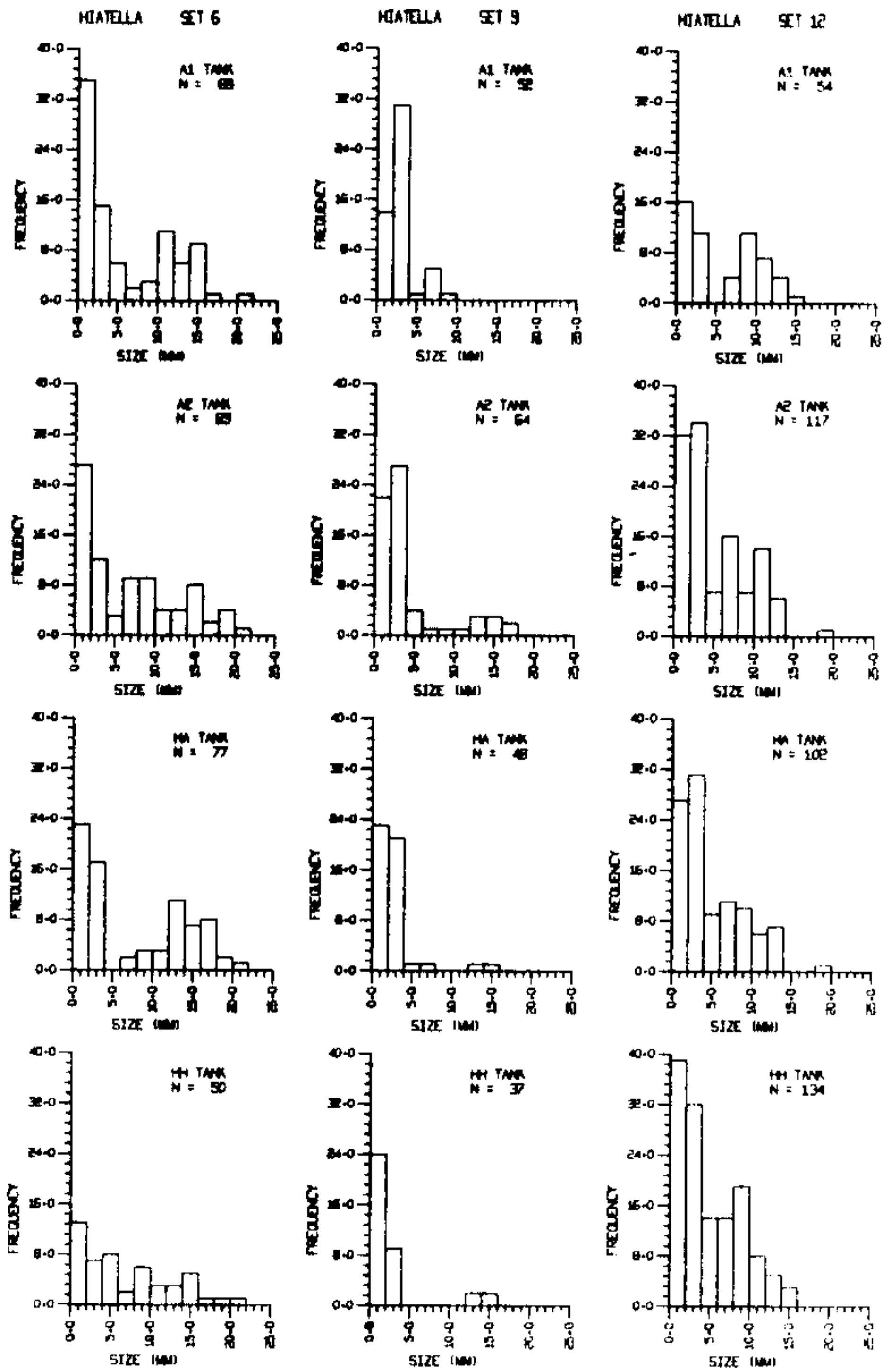


Figure 17. "Size at which reproduction was initiated in Hiatella arctica." Cross-hatching indicates specimens which contained ova or spermatozoa three months after the beginning of the experiment.

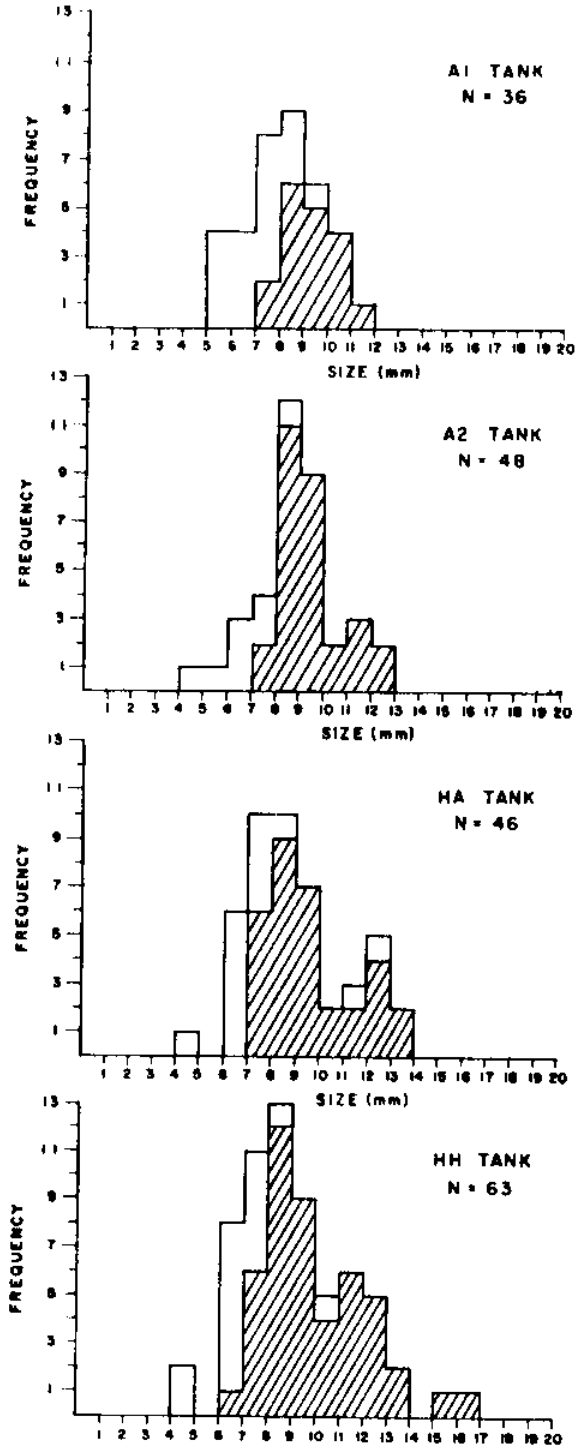


Figure 18. Size-frequency histograms for Mytilus edulis. Continued on the following page. Note that frequency and size scales differ between sets.

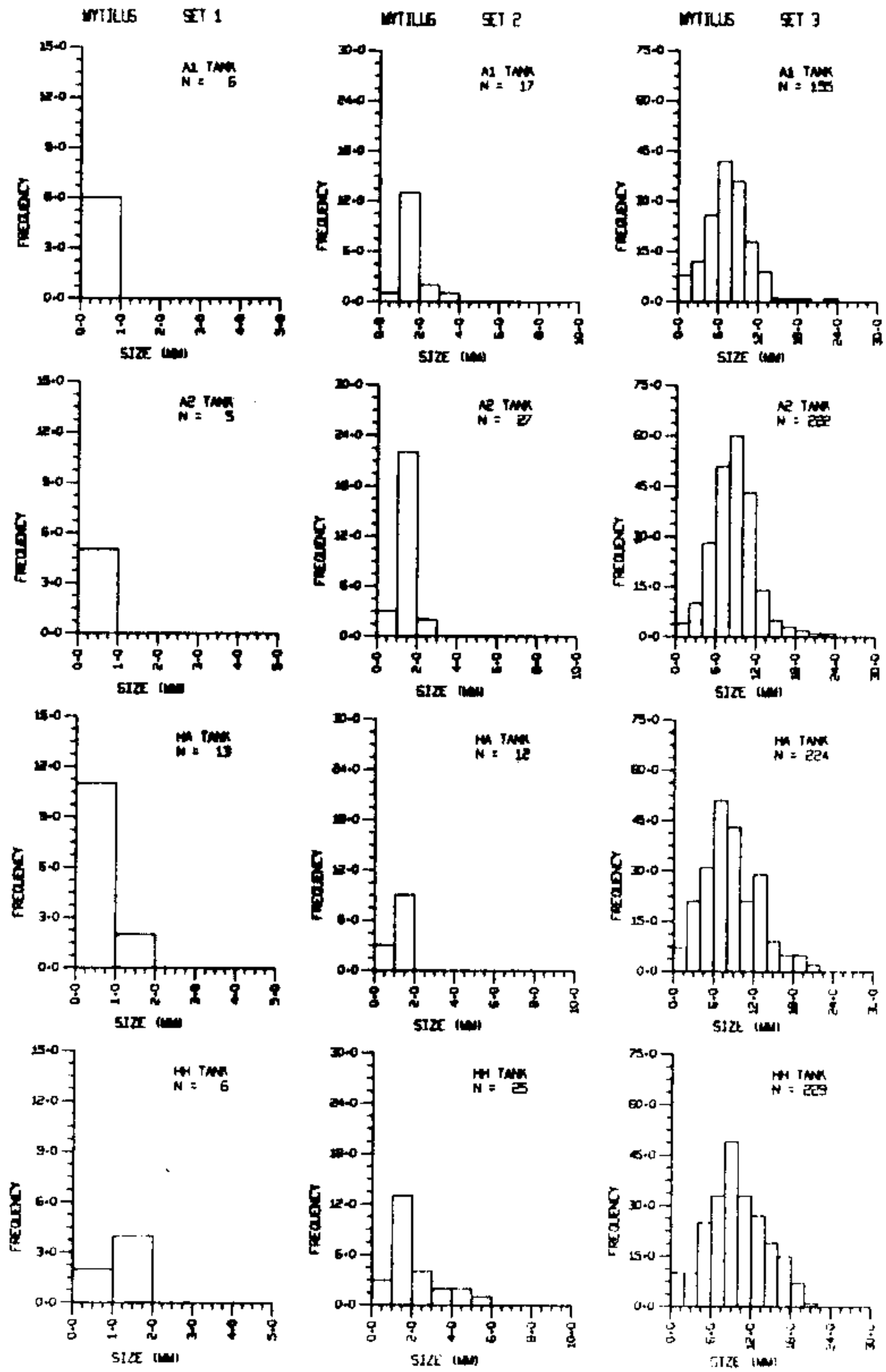


Figure 18. Continued.

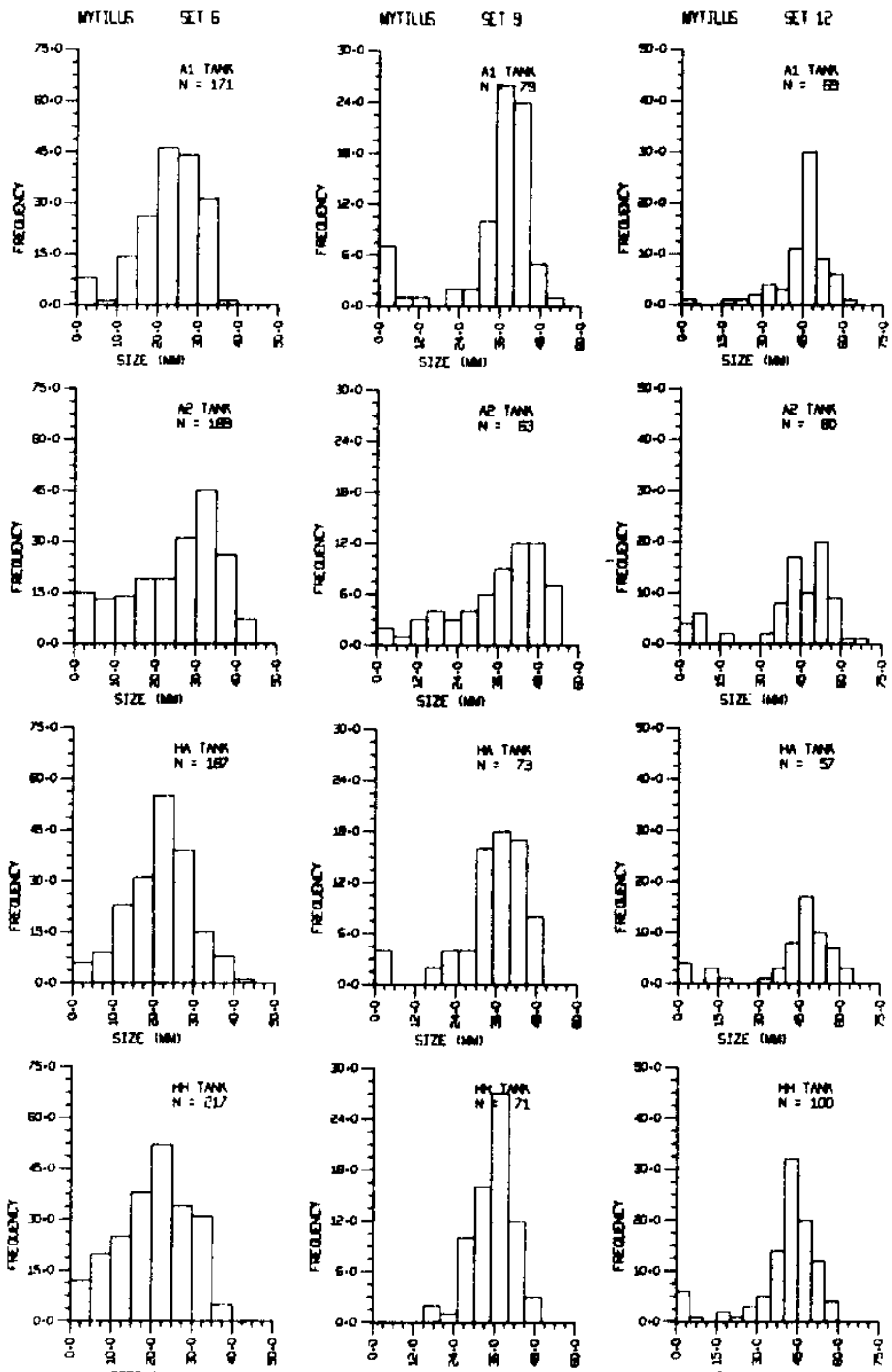


Figure 19. Size-frequency histograms for *Ostrea lurida*.

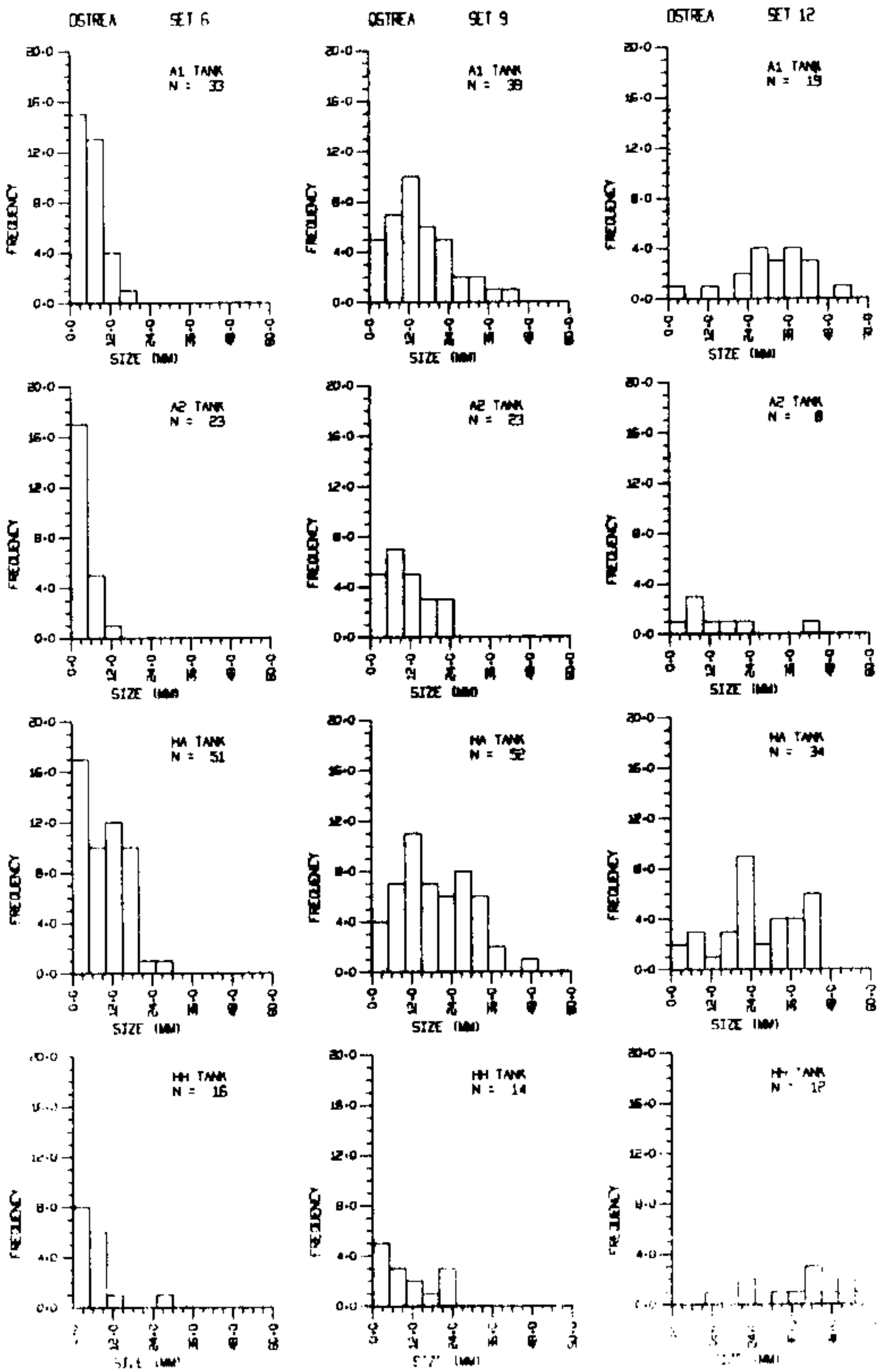


Figure 20. Median number of species per quadrat on the long-term series of plates.

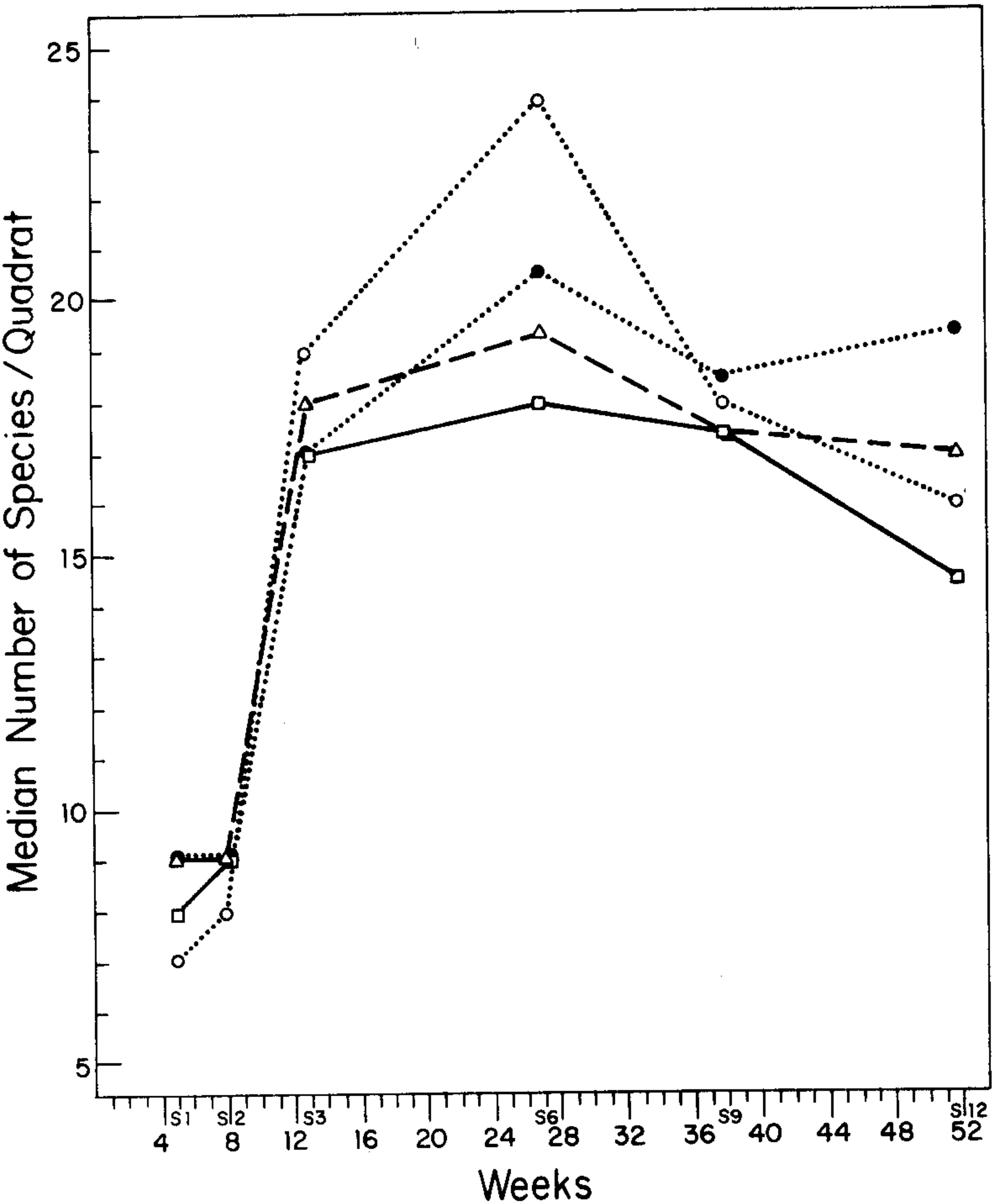


Figure 21. Median Shannon-Wiener diversity index per quadrat on the long term series of plates.

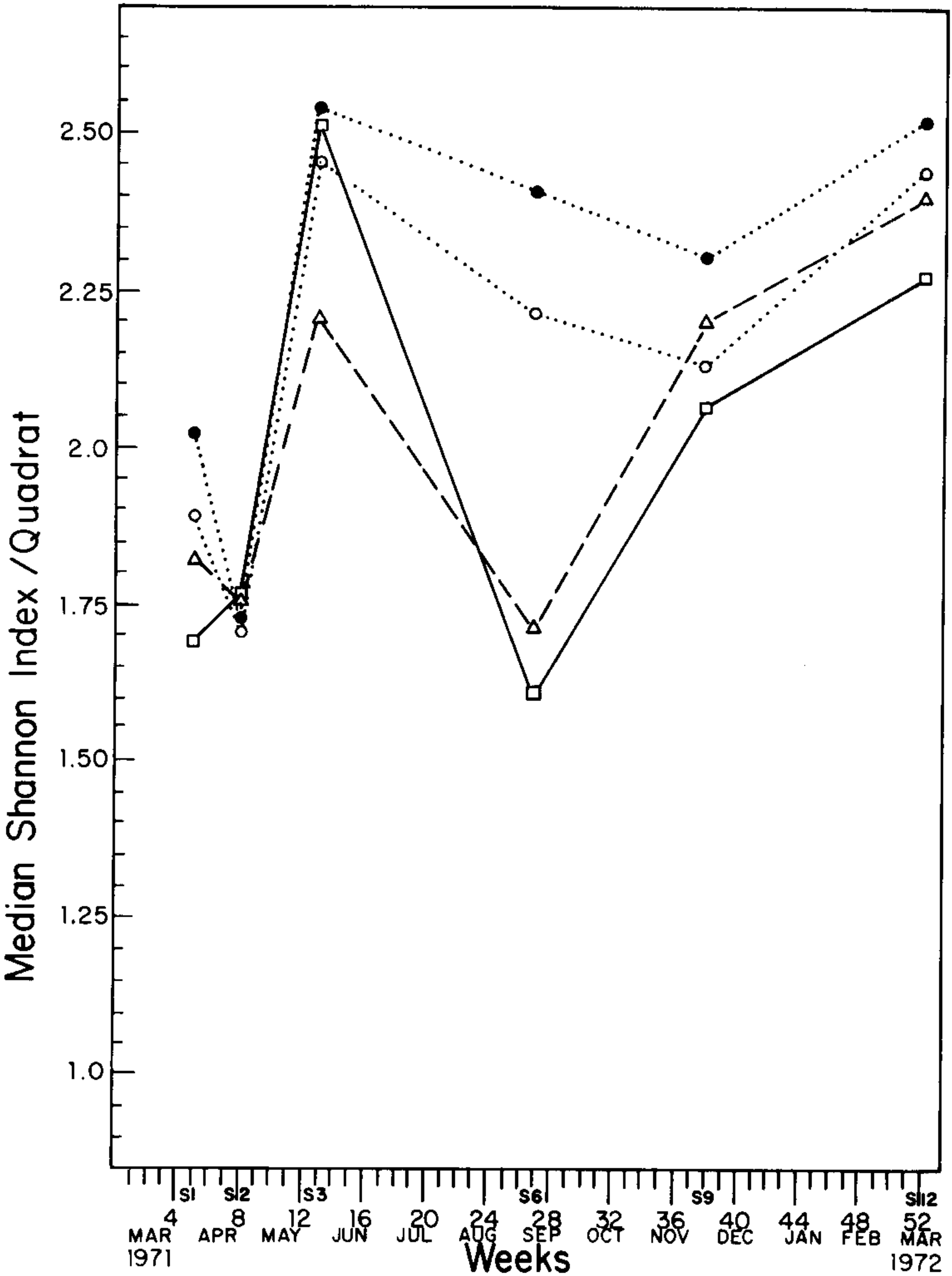


Table 1. List of species and species groups which settled in the experimental sea water system. Taxa counted on the plates are indicated by an asterisk (*). Opisthobranchs were not counted because of their motility. Other species not preceded by an asterisk occurred only on the sea table, or on the bottom or walls of the aquaria.

Porifera
- Calcarea
  - *Leucosolenia botryoides (Ellis and Solander)
  - *Scypha ciliata (Fabricius)
  - *Leuconia barbata (Duchassing and Michelotti)

Coelenterata
- Anthozoa
  - Diadumene sp.

Ectoprocta
- Cyclostomata
  - *Crisia occidentalis Trask
  - *Filicrisia franciscana (Robertson)
- Cheilostomata
  - *Aetea anguina (Linnaeus)
  - *Bugula mollis (J. V. Thompson)
  - *Cryptosula pallasiana (Moll)
  - Membranipora serrilamella Osburn
  - *Scruparia ambigua (d'Orbigny)
  - Scrupocellaria sp.
- Ctenostomata
  - *Amathia distans Busk
  - *Bowerbankia gracilis Leidy

Entoprocta
- Loxosomatidae
  - *Loxosoma sp.
- Pedicellinidae
  - *Pedicellina cernua (Pallas)
  - *Barentsia discreta (Busk)

Mollusca
- Gastropoda (excluding Opisthobranchia)
  - *Caecum spp.
  - Crepidula onyx Sowerby
  - Crepidula perforans (Valenciennes)
  - *Crepipatella lingulata (Gould)
  - Mitrella spp.
  - Norrisia norrisi (Sowerby)
  - Ocenebra poulsoni (Carpenter)
  - *Serpulorbis squamigerus (Carpenter)
  - Tegula sp.

Opisthobranchia

- Ancula lentiginosa Farmer and Sloan
- Ancula pacifica MacFarland
- Antiopella aureocincta MacFarland
- Corambella bolini MacFarland
- Dendronotus frondosus (Ascanius)
- Dirona picta MacFarland
- Hermissenda crassicornis (Eschscholtz)
- Okenia angelensis Lance
- Polycera sp.
- Triopha carpenteri (Stearns)
- Triopha maculatus MacFarland

Bivalvia

- Adula diegensis (Dall)
- Aequipecten aequisulcatus (Carpenter)
- *Chama pellucida Broderip
- *Chione sp.
- *Hiatella arctica (Linnaeus)
- *Hinnites multirugosus (Gale)
- *Kellia laperousii Deshayes
- Laevicardium substriatum (Conrad)
- *Leptopecten latiauratus (Conrad)
- Lima hemphilli Hertlein and Strong
- *Mytilus edulis Linnaeus
- *Ostrea lurida Carpenter
- Petricola tellimyalis (Carpenter)
- *Pholadidae
- *Pododesmus cepio (Gray)
- Tresus nutallii (Conrad)

Annelida

Chrysopetalidae

- *Chrysopetalum occidentale Johnson

Cirratulidae

- Cirratulus cirratus (Muller)

Polynoidae

- Halosydna latior Chamberlin

Sabellariidae

- *Sabellaria cementarium Moore

Sabellidae

- *Chone mollis (Bush)
- Chone minuta Hartman
- Megaloma roulei (Gravier)

Serpulidae

- *Eupomatus gracilis Bush
- *Serpula vermicularis Linnaeus
- *Spriobranchis spinosus Moore
- *Dexiospira sp.

Spionidae

- *Polydora sp.

Syllidae
- *Odontosyllis phosphorea Moore
- Typosyllis variegata (Grube)

Terebellidae
- *Amphitrite cirrata (Muller)
- *Pista brevibranchiata Moore
- Pista elongata Moore

Arthropoda

Pycnogonida
- *Anoplodactylus erectus Coles

Cirripedia
- *Balanus glandula Darwin
- *Balanus pacificus Pilsbry
- *Balanus tintinnabulum californicus Pilsbry
- *Balanus trigonus Darwin
- *Chthamalus fissus Darwin
- *Pollicipes polymerus (Sowerby)

*Copepoda

Isopoda
- Idothea fewkesi (Richardson)

Amphipoda
- *Gammaridea
- Caprellidea
  - *Caprella angusta Mayer
  - *Caprella californica Stimpson
  - *Caprella verrucosa Boeck

Decapoda
- Betaeus longidactylus Lockington
- Lophopanopeus frontalis (Rathbun)
- Lophopanopeus heathii Rathbun
- Pilumnus spinohirsutus (Lockington)

Echinodermata

Echinoidea
- *Strongylocentrotus sp.

Holothuroidea
- Leptosynapta sp.

Ophiuroidea
- Ophiopteris papillosa (Lyman)
- Ophiothrix spiculata LeConte

Chordata

Ascidiacea
- *Ascidia ceratodes (Huntsman)
- *Molgula verrucifera Ritter and Forsyth
- *Styela barnhardi Ritter and Forsyth
- Styela montereyensis (Dall)
- *various colonial ascidians

Table 2. Size and abundance data for Leucosolenia botryoides (size = number of branches/colony)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(6)				SET 9(6)				SET 12(6)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#									0	1	3	1	52	193	4	7	41	53	31	20	21	42	11	21
Mn.#/Q									0	0.1	0.3	0.1	8.7	32.2	0.7	1.2	6.9	8.9	5.2	3.3	3.5	7.0	1.8	3.5
Md.#/Q									0	0	0	0	8	32 ** **	0 **	1 **	7	9 *	5	3 *	3	7 *	2 *	3
Mn.Size									--	35	8.7	70	13.0	19.2	4.0	15.4	11.4	12.6	12.9	14.1	5.1	8.8	8.1	7.8
Md.Size									--	35	4	70	7.5 **	14 ** *	4 *	9.5	9	10	10.5	11	5 ** *	8 **	8 *	7
Mn.#Br./Q									0	3.9	2.9	7.8	112	617	2.7	18.0	79.5	113	66.8	46.3	17.5	61.8	14.8	27.5
Md.#Br./Q									0	0	0	0	45.5	584 ** *	0 **	14 *	71.5	128	56	27	14	65.5 *	13.5 *	19.5

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#									1	3	0	2	6	12	2	1	20	181	16	6
Mn.#/Q									0.2	0.6	0	0.4	1.2	2.4	0.4	0.2	4.0	36.2	3.2	1.2
Md.#/Q									0	0	0	0	1	2	0	0	5	36 **	4	1 **
Mn.Size									7	1.0	--	1.0	2.2	2.0	2.0	1.0	8.9	24.6	2.6	4.0
Md.Size									7	1	--	1	2	2	2	1	6 **	21 ** ** **	2 **	3 **
Mn.#Br./Q									1.4	0.6	0	0.4	2.6	4.8	0.8	0.2	35.6	892	8.2	4.8
Md.#Br./Q									0	0	0	0	2	6	0	0	34	939 ** *	11 *	6 **

Table 3. Size and abundance data for <u>Scypha ciliata</u> (size = length in mm)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(6)				SET 9(6)				SET 12(6)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#													0	0	0	71	0	1	0	20	0	0	0	3
Mn.#/Q													0	0	0	11.8	0	0.2	0	3.3	0	0	0	0.5
Md.#/Q													0 *	0 *	0 *	10.5 * * *	0	0	0	4.5	0	0	0	0
Mn.Size													--	--	--	0.7	--	2.8	--	3.2	--	--	--	10.5
Md.Size													--	--	--	0.5	--	2.8	--	3.0	--	--	--	10.0

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#									0	0	0	15	0	1	0	11	0	4	0	77
Mn.#/Q									0	0	0	3.0	0	0.2	0	2.5	0	0.8	0	15.4
Md.#/Q									0	0	0	2	0	0	0	2	0 *	1	0 *	14 * *
Mn.Size									--	--	--	2.7	--	6.0	--	3.0	--	3.2	--	5.8
Md.Size									--	--	--	2.3	--	6.0	--	2.6	--	3.2	--	5.0

Table 4. Size and abundance data for <u>Leuconia barbata</u> (size = number of branches/colony)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#													0	1	0	1	0	0	15	0	0	0	20	0
Mn.#/Q													0.1	0	0.1	0	0	0	1.7	0	0	0	2.2	0
Md.#/Q													0	0	0	0	0	0	2	0	0	0	1	0
Mn.Size													3	--	5	--	--	--	4.6	--	--	--	1.6	--
Md.Size													3	--	5	--	--	--	1	--	--	--	1	--
Mn.#Br./Q													0.3	0	0.5	0	0	0	7.7	0	0	0	3.7	0
Md.#Br./Q													0	0	0	0	0	0	0	0	0	0	2	0

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#																				
Mn.#/Q																				
Md.#/Q																				
Mn.Size																				
Md.Size																				
Mn.#Br./Q																				
Md.#Br./Q																				

Table 5. Size and abundance data for <u>Crisia occidentalis</u> (size = number of branches/colony)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(6)				SET 9(6)				SET 12(6)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	18	19	11	26	53	37	41	58	46	41	46	75	73	81	99	47	77	77	103	45	31	63	125	22
Mn.#/Q	2.0	2.1	1.2	2.9	5.9	4.1	4.6	6.4	5.1	4.6	5.1	8.3	12.2	13.5	16.5	7.8	12.9	12.9	17.2	7.5	5.2	10.5	20.8	3.7
Md.#/Q	2	2	1	3	6	4	4	7	5 *	4 **	6 *	8 ** * *	12	11.5	17.5 *	8.5 *	13	14	16.5 *	7 *	5 **	10	20.5 ** **	3 **
Mn.Size	2.7	2.1	3.0	3.7	7.6	9.2	11.9	19.7	18.9	29.6	26.9	43.9	16.9	20.9	13.9	18.1	10.8	18.4	19.1	8.7	7.9	9.9	14.9	8.2
Md.Size	2	2 *	2	3 *	5 **	7 *	9	12 ** *	12	17	18.5	12	12 **	16 **	6 ** ** **	14 **	8	10	12 *	6 *	5 *	6 *	10 * * *	4.5 *
Mn.#Br./Q	5.3	4.6	3.8	10.6	44.9	37.9	54.0	127	96.4	135	137	365	205	282	228	142	139	236	329	65.2	41.2	104	310	30.0
Md.#Br./Q	7	5	2	10	44 *	34 **	46	132 ** *	103 **	109 *	129 *	293 ** * *	185	286	181	156	149	249 *	250 *	64 * *	35.5 **	104	298 ** **	18 **

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	1	0	1	3	1	74	3	8	94	7	330	2	34	2	0	0	67	63	47	0
Mn.#/Q	0.1	0	0.1	0.3	0.1	8.2	0.3	0.9	18.8	1.4	66.0	0.4	6.8	0.4	0	0	13.4	12.6	9.4	0
Md.#/Q	0	0	0	0	0 **	7 ** ** *	0 **	1 *	19	0 **	61 ** **	0 **	7 * *	0	0 *	0 *	18 *	12 *	7	0 * *
Mn.Size	4	--	6	8.3	1	1.9	1.0	5.1	1.5	2.0	3.2	3.0	2.0	4.0	--	--	2.6	9.2	2.2	--
Md.Size	4	--	6	6	1	2	1	3.5	1 **	2	1 **	3	2	4	--	--	2 **	6 ** **	2 **	--
Mn.#Br./Q	0.4	0	0.7	2.8	0.1	15.8	0.3	4.6	28.2	2.8	212	1.2	13.4	1.6	0	0	35.2	11.0	21.0	0
Md.#Br./Q	0	0	0	0	0 **	14 ** **	0 **	1	26	0 **	221 ** **	0 **	10 * *	0	0 *	0 *	19	139 **	18	0 **

Table 6. Size and abundance data for Filicrisia franciscana (size = number of branches/colony)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(6)				SET 9(6)				SET 12(6)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	1	1	2	6	9	5	2	9	12	7	16	73	145	155	173	54	73	117	138	13	49	50	89	6
Mn.#/Q	0.1	0.1	0.2	0.7	1.0	0.6	0.2	1.0	1.3	0.8	1.8	8.1	24.2	25.8	28.8	9.0	12.2	19.5	23	2.2	8.2	8.3	14.8	1.0
Md.#/Q	0	0	0	0	1	0	0	1	1	1 **	1	6 **	23.5	27 *	30 **	8.5 ** *	11.5	21.5 **	23 **	2.5 ** **	8.5	8	12.5 **	0 **
Mn.Size	3	4	6.0	15.2	46	37.2	25.5	112	90.4	173	57.8	20.2	37.5	77.5	34.1	51.1	20.5	34.9	23.8	12.8	12.2	16.9	18.8	65.7
Md.Size	3	4	6	11	55	12	25.5	110	25 *	200 ** **	1 **	3 ** *	19 **	32 ** **	16 ** *	26 *	16 *	28 ** ** *	17 **	16 **	9 ** *	13.5 *	15 *	75.5 ** *
Mn.#Br./Q	0.3	0.4	1.3	10.1	46.0	20.7	5.7	112	121	134	103	164	905	2003	983	460	249	680	548	27.7	99.3	141	278	65.7
Md.#Br./Q	0	0	0	0	6	0	0	70	50	40	20	125	802	1843 **	515	616 **	251	706 **	552 **	26.5 ** **	96.5	107	264 *	0 *

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	1	1	0	1	5	59	174	116	425	116	669	4	188	396	265	215	402	423	1101	22
Mn.#/Q	0.1	0.1	0	0.1	0.6	6.6	19.3	12.9	85.0	23.2	134	0.8	37.6	79.2	53.0	43.0	80.4	84.6	220	4.4
Md.#/Q	0	0	0	0	0 ** **	5	18 **	11 **	88 *	17 *	118 ** *	1 ** *	36	64	50	32	81	85	221 **	2 **
Mn.Size	10	4	--	2	1.6	1.8	1.0	4.4	5.2	1.7	6.7	9.5	6.3	8.3	5.2	2.9	19.7	18.2	8.3	14.3
Md.Size	10	4	--	2	2	1 **	1 ** **	1 **	1 **	1 ** **	1 **	1	2 ** *	4 ** ** **	3 ** ** *	2 ** **	11 ** **	5 ** **	3 ** **	8.5
Mn.#Br./Q	1.1	0.4	0	0.2	0.9	12.0	19.3	56.8	446	38.6	902	7.6	239	658	277	125	1583	1543	1829	62.8
Md.#Br./Q	0	0	0	0	0 ** **	15	18 **	50 **	460	19 *	991 ** *	1 **	219	388 **	256	101 **	1412	1568	1769 **	9 **

Table 7. Size and abundance data for Amathia distans (size = number of branches/colony)

	SET 1(9)				SET 2(9)				SET 3(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#												
Mn.#/Q												
Md.#/Q												
Mn.Size												
Md.Size												
Mn.#Br./Q												
Md.#Br./Q												

	SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	0	0	1	23	0	0	0	26	0	0	13	69
Mn.#/Q	0	0	0.1	2.6	0	0	0	4.3	0	0	1.4	7.7
Md.#/Q	0	0	0	3	0	0	0	4	0	0	0	9
Mn.Size	--	--	24	2.7	--	--	--	3.3	--	--	6.1	24.9
Md.Size	--	--	24	1	--	--	--	3	--	--	7 **	11 **
Mn.#Br./Q	0	0	2.7	6.8	0	0	0	14.5	0	0	8.8	191
Md.#Br./Q	0	0	0	4	0	0	0	10	0	0	0	54

	SET 1b(9)				SET 1c(9)				SET 1d(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#												
Mn.#/Q												
Md.#/Q												
Mn.Size												
Md.Size												
Mn.#Br./Q												
Md.#Br./Q												

	SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH
Total#					0	0	0	36
Mn.#/Q					0	0	0	7.2
Md.#/Q					0	0	0	4
Mn.Size					--	--	--	26.9
Md.Size					--	--	--	19
Mn.#Br./Q					0	0	0	194
Md.#Br./Q					0	0	0	45

Table 8. Abundance data for Bowerbankia gracilis*

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(6)				SET 9(6)				SET 12(6)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#													--	--	--	--	--	--	--	--	--	--	--	--
Mn.#/Q													--	--	--	--	--	--	--	--	--	--	--	--
Md.#/Q													--	--	--	--	--	--	--	--	--	--	--	--
Mn.Size													--	--	--	--	--	--	--	--	--	--	--	--
Md.Size													--	--	--	--	--	--	--	--	--	--	--	--
Mn.# ./Q													578	522	1044	780	IV	II	I	III	IV	II	I	III
Md.# ./Q													678	330	1063	660	--	--	--	--	--	--	--	--

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#													--	--	--	--	--	--	--	--
Mn.#/Q													--	--	--	--	--	--	--	--
Md.#/Q													--	--	--	--	--	--	--	--
Mn.Size													--	--	--	--	--	--	--	--
Md.Size													--	--	--	--	--	--	--	--
Mn.# ./Q													0	0	517	0	0	0	452	278
Md.# ./Q													0 *	0 *	403 ***	0 *	0 *	0 *	444 **	126

* Set 9 and 12 roman numerals indicate rank order of abundance (see text for explanation)

Table 9. Size and abundance data for *Aetea anguina* (size = number of zooids/colony)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(6)				SET 9(6)				SET 12(6)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#													30	76	17	46	1	0	5	0	0	34	0	0
Mn.#/Q													5.0	12.7	2.8	7.7	0.2	0	0.8	0	0	5.7	0	0
Md.#/Q													4.5	9	1	7	0	0	0	0	0 *	2 * * *	0 *	0 *
Mn.Size													21.9	41.0	15.6	23.0	5.0	--	17.0	--	--	12.6	--	--
Md.Size													18	27 *	4 *	32	5	--	14	--	--	4	--	--
Mn.#Zd./Q													110	520	44.2	177	0.8	0	14.2	0	0	71.2	0	0
Md.#Zd./Q													70.5	159	4.5	217	0	0	0	0	0 *	18.5 * * *	0 *	0 *

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#					1	1	0	2	0	0	0	4	1	0	6	3	3	1	2	53
Mn.#/Q					0.1	0,1	0	0.2	0	0	0	0.8	0.2	0	1.2	0.6	0.6	0.2	0.4	10.6
Md.#/Q					0	0	0	0	0	0	0	0	0	0	2	0	0	0 *	0	6 *
Mn.Size					2	4	--	4.5	--	--	--	23.0	3.0	--	2.3	3.0	11.3	3	5.0	21.5
Md.Size					2	4	--	4.5	--	--	--	22.5	3	--	2	4	7	3	5	18
Mn.# Zd./Q					0.2	0.4	0	1	0	0	0	18.4	0.6	0	2.8	1.8	6.8	0.6	2.0	228
Md.# Zd./Q					0	0	0	0	0	0	0	0	0	0	4	0	0	0 *	0	120 *

Table 10. Size and abundance data for <u>Bugula mollis</u> (size = number of branches/colony)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(6)				SET 9(6)				SET 12(6)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#									0	0	0	141	222	24	0	175	209	39	2	189	75	18	0	29
Mn.#/Q									0	0	0	15.7	37.0	4.0	0	29.2	34.8	6.5	0.3	31.5	12.5	3.0	0	4.8
Md.#/Q									0 **	0 **	0 **	8 ** ** **	24.5 **	3.5	0 ** **	30 **	36 **	6.5	0 ** **	34.5 **	13 **	2.5	0 **	3.5
Mn.Size									--	--	--	43.2	5.4	13.5	--	4.2	15.7	18.2	6.0	13.7	8.2	5.1	--	8.7
Md.Size									--	--	--	25	4 **	12 ** **	--	4 **	12	14	6	12	7 **	4 **	--	6
Mn.#Br./Q									0	0	0	678	201	54.2	0	122	548	119	2.0	430	103	15.3	0	41.8
Md.#Br./Q									0 **	0 **	0 **	398 ** ** **	137 **	37.5	0 ** **	144 **	590 **	92	0 ** **	449 **	104 **	11	0 ** *	18.5 *

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	0	0	0	2	0	0	0	338	315	22	28	6408	111	12	4	3	551	121	2	917
Mn.#/Q	0	0	0	0.2	0	0	0	43.1	63.0	4.4	5.6	1278	22.2	2.4	0.8	0.6	110	24.2	0.4	183
Md.#/Q	0	0	0	0	0 **	0 **	0 **	37 ** ** **	64	4 **	5 *	1326 ** *	23 ** *	2	1 *	0 **	117	15	0 **	180 **
Mn.Size	--	--	--	10	--	--	--	7.4	5.9	1.2	1.9	2.4	1.3	7.3	1.3	1.0	4.5	6.0	6.0	1.1
Md.Size	--	--	--	10	--	--	--	1 .	1	1	1.5	1	1 **	4 ** * *	1 *	1 *	4 **	4 **	6 *	1 ** ** *
Mn.#Br./Q	0	0	0	2.2	0	0	0	321	369	5.4	10.4	3012	29.4	17.6	1.0	0.6	490	147	2.4	200
Md.#Br./Q	0	0	0	0	0 **	0 **	0 **	308 ** ** **	366 *	4 ** *	9 *	3096 ** *	29 * *	16	1 *	0 *	553 **	122	0 ** *	191 *

Table 11. Size and abundance data for Scruparia ambigua (size = number of branches/colony)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(6)				SET 9(6)				SET 12(6)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	15	16	36	29	125	78	99	93	124	108	96	75	25	25	24	7	10	33	7	3	0	5	4	0
Mn.#/Q	1.7	1.8	4.0	3.2	13.9	8.7	11.0	10.3	13.8	12.0	10.7	8.3	4.2	4.2	4.1	1.1	1.7	5.5	1.2	0.5	0	0.8	0.7	0
Md.#/Q	2	2	4	3	11	10	8	10	15 *	11	10	9 *	3	4 *	4 *	1 * *	1.5	5 ** *	0 *	0 **	0	0.5	0.5	0
Mn.Size	5.8	7.5	5.3	5.0	14.5	13.1	9.9	16.0	24.9	20.5	11.8	10.7	9.0	8.6	8.2	8.0	2.2	2.8	3.3	3.3	--	3.6	6.8	--
Md.Size	6	8.5	4.5	3	10	9.5	5 *	10 *	15 * *	14	8 *	7.5 *	8	8	7.5	6	2.5	1	2	2	--	3	7	--
Mn.#Br./Q	9.7	13.3	21.0	16.2	201	113	109	165	343	246	126	89.0	38.0	36.5	33.5	8.7	3.7	15.3	3.8	1.7	0	3.0	4.5	0
Md.#Br./Q	6	9	16	16	174	106	78	162	329 * *	290	107 *	101 *	25.5	39 *	32.5 *	9 * *	3	15.5 *	0	0 *	0	1	1.5	0

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	48	57	31	37	10	132	1	3	166	2	205	0	13	0	1	0	74	3	83	1
Mn.#/Q	5.3	6.3	3.4	4.1	2.6	14.7	0.1	0.3	33.2	0.4	41.0	0	2.6	0	0.2	0	14.8	0.6	16.6	0.2
Md.#/Q	5	6 *	2 *	4	3	0 * *	0 *	0 *	19 *	0 *	38 * *	0 * *	3 * *	0 *	0	0 *	8 *	0 *	18 * *	0 * *
Mn.Size	10.9	14.1	11.3	5.5	1.5	1.9	3	2.0	3.6	1	7.1	--	2.2	--	1	--	4.0	3.0	3.9	1
Md.Size	6	5	10 *	4 *	1	2	3	2	2 *	1 *	5 * *	--	1	--	1	--	3	2	3	1
Mn.#Br./Q	58.1	89.2	38.8	22.8	1.7	0	0.7	0	121	0.4	292	0	5.8	--	0.2	--	59.0	1.8	64.8	0.2
Md.#Br./Q	54 *	72 * *	21 *	18 * *	1	28	0	0	66	0 *	292 * *	0 *	5 * *	0 *	0	0 *	25 *	0 *	56 * *	0 * *

Table 12. Size and abundance data for *Cryptosula pallasiana* (size = actual or estimated number of zooids/colony)*

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#					0	2	1	2	2	1	0	2	96	23	73	12	17	7	32	4	8	10	13	3
Mn.#/Q					0	0.2	0.1	0.2	0.2	0.1	0	0.2	10.7	2.5	8.1	1.3	1.9	0.8	3.5	0.4	0.9	1.1	1.4	0.3
Md.#/Q					0	0	0	0	0	0	0	0	13	2	8	1	2	1	3 *	0 *	1	1	1	0
Mn.Size					--	120	2	406	109	420	--	489	66.7	20.8	63.0	887	74.4	48.8	309	84.2	164	427	347	2630
Md.Size					--	120	2	406	109	420	--	489	1 *	2	1 *	38 * *	1	1	1	1.5	2	1	1	1025
Mn.#Zd./Q					0	26.7	0.2	90.2	24.3	46.7	0	109	713	53.2	509	1183	140	38.0	1101	37.4	145	473	502	876
Md.#Zd./Q					0	0	0	0	0	0	0	0	17	6	14	48	2	1	4	0	1	1	1	0

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	0	2	0	0					4	16	6	39	346	292	362	174	162	78	207	28
Mn.#/Q	0	0,2	0	0					0.8	3.2	1.2	7.8	69.2	58.4	72.4	34.8	32.4	15.6	41.4	5.6
Md.#/Q	0	0	0	0					0 **	2	1 *	7 ** *	56 *	47	74 *	31 * *	34 *	15	36 **	6 ** *
Mn.Size	--	62	--	--					1	1.2	1.2	1.7	1.9	2.9	2.6	4.5	9.0	1.8	1.5	6.1
Md.Size	--	62	--	--					1	1	1	2	2 *	2 *	2 *	3 * * *	1 *	2 * *	1 *	1
Mn.# Zd./Q	0	13,8	0	0					0.8	3.8	1.4	13.2	134	172	191	158	291	28.4	63.8	34.4
Md.# Zd./Q	0	0	0	0					0 **	2	1 *	11 ** *	131	123	203	121	151	28	47	10

Table 13. Size and abundance data for <u>Barentsia discreta</u> (size = number of zooids/colony)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(6)				SET 12(6)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#													2	0	6	1	--	--	--	--	--	--	--	--
Mn.#/Q													0.2	0	0.7	0.1	--	--	--	--	--	--	--	--
Md.#/Q													0	0	0	0	--	--	--	--	--	--	--	--
Mn.Size													84.5	--	70.2	260	--	--	--	--	--	--	--	--
Md.Size													84.5	--	40	260	--	--	--	--	--	--	--	--
Mn.#Br./Q													18.7	0	46.8	28.9	84.0	678	1440	472	III	IV	II	I
Md.#Br./Q													0	0	0	0	36 **	738	1500 **	498	--	--	--	--

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#																	0	0	1	1
Mn.#/Q																	0	0	0.2	0.2
Md.#/Q																	0	0	0	0
Mn.Size																	--	--	196	259
Md.Size																	--	--	196	259
Mn.#Br./Q																	0	0	39.2	51.8
Md.#Br./Q																	0	0	0	0

* Set 9 and 12 colonies were indistinct; set 12 roman numerals indicate rank order of abundance (see text for explanation)

Table 14. Abundance data for Loxosoma sp. (All individuals were between 1 and 2 mm in length)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(6)				SET 9(6)				SET 12(6)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#													43	12	156	0								
Mn.#/Q													7.2	1.8	25.8	0								
Md.#/Q													0	0	20.0 *	0 *								
Mn.Size													--	--	--	--								
Md.Size													--	--	--	--								

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#													0	0	2250	0	0	0	243	18
Mn.#/Q													0	0	510	0	0	0	46.8	3.6
Md.#/Q													0 *	0 *	312 * * *	0 *	0	0	12	0
Mn.Size													--	--	--	--	--	--	--	--
Md.Size													--	--	--	--	--	--	--	--

Table 15. Size and abundance data for *Caecum* spp. (size = length in mm)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#													1	0	0	0	1	3	0	5	3	7	0	15
Mn.#/Q													0.1	0	0	0	0.1	0.3	0	0.5	0.3	0.8	0	1.7
Md.#/Q													0	0	0	0	0	0	0	0	0	1	0	1
Mn.Size													2.3	--	--	--	1.7	1.8	--	1.8	1.7	1.8	--	2.0
Md.Size													2.3	--	--	--	1.7	1.7	--	1.7	1.7	2.0	--	1.9

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#																				
Mn.#/Q																				
Md.#/Q																				
Mn.Size																				
Md.Size																				

Table 16. Size and abundance data for <u>Crepipatella lingulata</u> (size - maximum diameter in mm)

	SET 1(9)				SET 2(9)				SET 3(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#					1	1	0	0	1	5	1	0
Mn.#/Q					0.1	0.1	0	0	0.1	0.6	0.1	0
Md.#/Q					0	0	0	0	0	0	0	0
Mn.Size					1.3	1.8	--	--	0.7	2.7	2.2	--
Md.Size					1.3	1.8	--	--	0.7	1.7	2.2	--

	SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	8	20	11	9	15	12	11	17	18	19	23	13
Mn.#/Q	0.9	2.2	1.2	1.0	1.7	1.3	1.2	1.9	2.0	2.1	2.6	1.4
Md.#/Q	1	1	1	1	1	1	1	1	2	2	3	1
Mn.Size	5.3	6.2	6.8	4.5	9.8	8.2	10.5	8.8	11.0	11.5	11.0	9.7
Md.Size	4.8	4.7	7.5	3.3	12.2	8.0	9.2	9.8	11.3	10.3	10.5	8.2

	SET 1b(9)				SET 1c(9)				SET 1d(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#									2	2	0	0
Mn.#/Q									0.4	0.4	0	0
Md.#/Q									0	0	0	0
Mn.Size									2.5	2.5	--	--
Md.Size									2.5	2.5	--	--

	SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH
Total#					3	0	0	5
Mn.#/Q					0.6	0	0	1
Md.#/Q					1	0	0	1
Mn.Size					6.7	--	--	4.2
Md.Size					5.8	--	--	4.2

Table 17. Size and abundance data for *Serpulorbis squamigerus* (size = length in mm)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#													6	2	12	1	5	0	5	3	7	4	3	1
Mn.#/Q													0.7	0.2	1.3	0.1	0.5	0	0.5	0.3	0.8	0.4	0.3	0.1
Md.#/Q													0	0	1	0	0	0	0	0	0	0	0	0
Mn.Size													1.7	1.8	2.7	0.7	3.9	--	9.7	6.7	16.4	6.5	7.7	18.3
Md.Size													1.4	1.8	3.2	0.7	3.7	--	10.3	5.7	18.5	5.5	2.7	18.3

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#													2	1	0	1	7	0	4	0
Mn.#/Q													0.4	0.2	0	0.4	1.4	0	0.8	0
Md.#/Q													0	0	0	0	1	0	1	0
Mn.Size													1.3	1.7	--	1.5	2.5	--	1.8	--
Md.Size													1.3	1.7	--	1.5	2.5	--	2.0	--

Table 18. Size and abundance data for bivalves too small to identify to genus (size = length in mm)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	21	27	41	35	13	12	9	8	25	35	22	42	32	18	17	17	7	1	3	7	0	0	3	0
Mn.#/Q	2.3	3	4.6	3.9	1.4	1.3	1.0	0.9	2.8	3.9	2.4	4.7	3.6	2.0	1.9	1.9	0.8	0.1	0.3	0.8	0	0	0.3	0
Md.#/Q	2	3	5	4	1	2	0	1	2	3	2	5	3	2	2	2	0	0	0	1	0	0	0	0
Mn.Size	0.5	0.5	0.7	0.7	0.8	0.7	0.7	0.5	0.7	0.7	0.5	0.7	0.7	0.8	0.7	0.7	0.8	0.7	0.7	1.2	--	--	0.7	--
Md.Size	0.5	0.5	0.7	0.5	0.7	0.5	0.7	0.5	0.5	0.7	0.5	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	--	--	0.7	--

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	4	3	4	1	6	34	26	14	22	34	24	16	0	1	2	1	15	1	6	9
Mn.#/Q	0.4	0.3	0.4	0.1	1.8	3.8	2.9	1.6	4.4	6.8	4.8	3.2	0	0.2	0.4	0.2	3	2.2	1.2	1.8
Md.#/Q	0	0	0	0	2	3	3	1	5	6	4	3	0	0	0	0	2	2	1	3
Mn.Size	0.7	0.5	0.3	0.8	0.5	0.5	0.3	0.5	0.5	0.5	0.7	0.5	--	0.5	0.5	0.5	0.7	0.7	0.7	0.7
Md.Size	0.6	0.5	0.4	0.8	0.5	0.5	0.4	0.5	0.5	0.5	0.7	0.5	--	0.5	0.5	0.5	0.7	0.7	0.7	0.7

Table 19. Size and abundance data for *Chama pellucida* (size = maximum length in mm)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#									0	0	1	0	6	3	5	4	8	1	5	4	2	6	9	4
Mn.#/Q									0	0	0.1	0	0.7	0.3	0.6	0.4	0.9	0.1	0.6	0.4	0.2	0.7	1	0.4
Md.#/Q									0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0
Mn.Size									--	--	1.3	--	1.8	1.8	1.7	3.7	4.3	3.0	8.3	4.8	7.8	7.8	6.2	8.8
Md.Size									--	--	1.3	--	2.0	1.5	1.3	1.3	4.7	3.0	6.2	4.1	7.8	8.2	4.8	9.1

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#																	2	5	2	1
Mn.#/Q																	0.4	1	0.4	0.2
Md.#/Q																	0	1	0	0
Mn.Size																	2.8	1.5	3.7	1.8
Md.Size																	2.8	1.3	3.7	1.8

Table 20. Size and abundance data for <u>Hiatella arctica</u> (size = length in mm)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(6)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	1	2	1	3	8	11	8	10	9	12	8	14	72	58	49	37	45	61	46	33	32	76	83	116
Mn.#/Q	0.1	0.2	0.1	0.3	0.9	1.2	0.9	1.1	1.0	1.3	0.9	1.6	12	9.7	8.2	6.2	5	6.8	5.1	3.7	3.6	8.4	9.2	12.9
Md.#/Q	0	0	0	0	0	1	1	1	1	1	1	1	13 *	10	8.5	6 *	5	7	5	3	3 ** *	9	10 *	12 **
Mn.Size	[illegible].2	1.5	2.5	2.3	3.0	2.8	3.7	6.0	5.5	7.2	9.5	8.7	4.7	5.0	4.3	5.5	2.5	4.0	2.5	1.8	3.3	2.8	4.0	4.3
Md.Size	[illegible].2	1.5	2.5	2.7	2.4	2.0 *	3.0	6.0 *	4.3	8.4	11.9	9.8	2.2	2.3	2.2	3.2	2.7 **	2.8 **	2.1	1.7 ** **	2.2	2.3	3.0	2.7

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	0	0	1	0	1	7	1	1	10	16	15	29	2	3	3	0	17	50	11	47
Mn.#/Q	0	0	0.1	0	0.1	0.8	0.1	0.1	2.0	3.2	3.0	5.8	0.4	0.6	0.6	0	3.4	10	2.2	9.4
Md.#/Q	0	0	0	0	0	1	0	0	1	3	3	8	0	1	1	0	3	9 *	2 * *	9 *
Mn.Size	--	--	2.5	--	0.7	1.2	1.0	0.7	1.2	0.8	1.3	1.2	1.0	1.2	1.0	--	2.8	2.0	3.2	3.3
Md.Size	--	--	2.5	--	0.7	1.0	1.0	0.7	1.1 *	0.7 ** * *	1.3 **	1.0 *	1.0	1.2	1.0	--	2.0	1.7 ** **	3.2 **	3.0 **

Table 21. Size and abundance data for _Hinnites multirugosus_ (size = hinge-line length in mm)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#									3	0	0	1	0	2	1	0	1	1	0	0	2	0	0	0
Mn.#/Q									0.3	0	0	0.1	0	0.2	0.1	0	0.1	0.1	0	0	0.2	0	0	0
Md.#/Q									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mn.Size									3.8	--	--	3.5	--	20.8	15.0	--	30.7	6.7	--	--	46.0	--	--	--
Md.Size									3.0	--	--	3.5	--	20.8	15.0	--	30.7	6.7	--	--	46.0	--	--	--

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#																	0	1	0	0
Mn.#/Q																	0	0.2	0	0
Md.#/Q																	0	0	0	0
Mn.Size																	--	16.5	--	--
Md.Size																	--	16.5	--	--

Table 22. Size and abundance data for <u>Leptopecten latiauratus</u> (size = hinge-line length in mm)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	0	0	2	1	3	0	1	0	2	0	0	0	0	2	0	0	0	1	0	0	1	0	3	0
Mn.#/Q	0	0	0.2	0.1	0.3	0	0.1	0	0.2	0	0	0	0	0.2	0	0	0	0.1	0	0	0.1	0	0.3	0
Md.#/Q	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mn.Size	--	--	0.8	0.8	2.5	--	1.8	--	12.0	--	--	--	--	3.8	--	--	--	6.0	--	--	2.0	--	9.3	--
Md.Size	--	--	0.8	0.8	1.8	--	1.8	--	12.0	--	--	--	--	3.8	--	--	--	6.0	--	--	2.0	--	7.8	--

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#																				
Mn.#/Q																				
Md.#/Q																				
Mn.Size																				
Md.Size																				

Table 23. Size and abundance data for <u>Kellia laperousii</u> (size = maximum diameter in mm)

	SET 1(9)				SET 2(9)				SET 3(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	5	8	4	1	0	3	5	2	1	2	1	1
Mn.#/Q	0.6	0.9	0.4	0.1	0	0.3	0.6	0.2	0.1	0.2	0.1	0.1
Md.#/Q	0	1	0	0	0	0	1	0	0	0	0	0
Mn.Size	1.5	1.3	2.8	3.7	--	2.0	3.8	3.7	8.3	4.0	8.5	7.0
Md.Size	1.0	1.3	2.9	3.7	--	2.2	3.5	3.7	8.3	4.0	8.5	7.0

	SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	0	3	0	0	5	2	0	1	2	12	17	15
Mn.#/Q	0	0.3	0	0	0.6	0.2	0	0.1	0.2	1.3	1.9	1.7
Md.#/Q	0	0	0	0	0	0	0	0	0	1	1	1
Mn.Size	--	7.3	--	--	1.8	2.2	--	1.3	1.8	1.5	1.8	2.8
Md.Size	--	6.8	--	--	1.7	2.2	--	1.3	1.8	1.3	1.8	1.8

	SET 1b(9)				SET 1c(9)				SET 1d(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	0	1	0	0	2	0	1	0				
Mn.#/Q	0	0.1	0	0	0.2	0	0.1	0				
Md.#/Q	0	0	0	0	0	0	0	0				
Mn.Size	--	0.7	--	--	1.0	--	1.2	--				
Md.Size	--	0.7	--	--	1.0	--	1.2	--				

	SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH
Total#								
Mn.#/Q								
Md.#/Q								
Mn.Size								
Md.Size								

Table 24. Size and abundance data for *Mytilus edulis* (size = length in mm)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	6	5	13	6	17	27	12	25	28	13	31	17	41	47	38	59	22	20	16	20	16	12	8	15
Mn.#/Q	0.7	0.5	1.4	0.7	1.9	3.0	1.3	2.8	3.1	1.4	3.4	1.9	4.5	5.2	4.2	6.5	2.4	2.2	1.8	2.2	1.8	1.3	0.9	1.6
Md.#/Q	0	0	1	0	2	4	1	3	2	1 *	4 *	2	4	4	3	5	3	1	2	2	2	1	1	1
Mn.Size	0.8	0.8	1.0	1.2	1.5	1.4	1.4	2.3	5.3	5.7	6.3	7.5	20.0	20.8	18.9	15.6	30.1	32.3	29.6	28.1	41.1	44.1	46.2	39.9
Md.Size	0.8 **	0.8 *	1.0	1.2 ** *	1.3	1.3 *	1.6	2.0 *	5.1	5.6	6.0	7.4	19.2	19.5	19.0	14.1	27.2	29.8	26.1	27.2	38.6	35.4	41.2	36.6

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	2	1	2	0	0	2	2	4					0	1	0	0	1	0	2	1
Mn.#/Q	0.2	0.1	0.2	0	0	0.2	0.2	0.4					0	0.2	0	0	0.2	0	0.4	0.2
Md.#/Q	0	0	0	0	0	0	0	0					0	0	0	0	0	0	0	0
Mn.Size	1.3	1.0	1.3	1.4	--	1.2	1.2	1.3					--	1.3	--	--	1.0	--	10.1	1.3
Md.Size	1.2	1.0	1.2	1.3	--	1.2	1.2	1.2					--	1.3	--	--	1.0	--	10.1	1.3

Table 25. Size and abundance data for <u>Ostrea lurida</u> (size = maximum diameter in mm)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#													9	8	20	6	18	7	23	9	15	13	19	11
Mn.#/Q													1.0	0.9	2.2	0.7	2.0	0.8	2.6	1.0	1.7	0.3	2.1	1.2
Md.#/Q													1	1	2	1	2	1	2	0	1	0	2	1
Mn.Size													3.8	4.0	9.2	7.2	17.3	5.2	16.5	10.7	31.0	24.2	24.7	41.8
Md.Size													3.0	4.0	7.7	2.7	15.3 *	3.5 * *	13.2 *	7.5	33.3	19.2	23.7 *	43.3 *

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#					0	1	0	0	11	4	12	3					15	20	15	8
Mn.#/Q					0	0.1	0	0	2.2	0.8	2.4	0.6					3.0	4.0	3.0	1.6
Md.#/Q					0	0	0	0	1	0	3	1					2	3	3	2
Mn.Size					--	1.7	--	--	2.0	1.0	3.0	1.7					2.5	5.7	5.3	5.5
Md.Size					--	1.7	--	--	2.0	1.0 **	2.5 **	1.5					1.3 **	5.1 **	3.0	4.7

Table 26. Size and abundance data for pholads (size = maximum diameter in mm)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	2	2	9	0	0	4	2	8	3	2	6	1	2	2	3	1	0	0	1	0				
Mn.#/Q	0.2	0.2	1.0	0	0	0.4	0.2	0.9	0.3	0.2	0.7	0.1	0.2	0.2	0.3	0.1	0	0	0.1	0				
Md.#/Q	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0				
Mn.Size	0.7	0.7	0.7	--	--	1.0	1.0	0.8	1.3	0.8	1.3	1.3	1.7	1.5	1.0	1.3	--	--	1.3	--				
Md.Size	0.7	0.7	0.8	--	--	1.0	1.0	0.8	1.3	0.8	1.3	1.3	1.7	1.5	1.0	1.3	--	--	1.3	--				

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#					1	13	0	2	2	0	0	0								
Mn.#/Q					0.1	1.4	0	0.2	0.4	0	0	0								
Md.#/Q					0	1	0	0	0	0	0	0								
Mn.Size					0.3	0.5	--	0.5	0.5	--	--	--								
Md.Size					0.3	0.5	--	0.5	0.5	--	--	--								

Table 27. Size and abundance data for <u>Pododesmus cepio</u> (size = maximum diameter in mm)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	0	2	0	4	2	3	2	1	2	3	3	4	5	5	1	1	5	6	0	1	6	2	0	0
Mn.#/Q	0	0.2	0	0.4	0.2	0.3	0.2	0.1	0.2	0.3	0.3	0.4	0.6	0.6	0.1	0.1	0.6	0.7	0	0.1	0.7	0.2	0	0
Md.#/Q	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Mn.Size	--	1.2	--	1.5	1.5	1.8	2.5	1.7	4.7	8.5	14.2	7.0	22.5	29.3	17.3	4.3	34.3	38.8	--	13.0	50.0	49.0	--	--
Md.Size	--	1.2	--	1.4	1.5	1.3	2.5	1.7	4.7	7.0	18.3	6.3	19.5	29.8	17.3	4.3	34.0	37.4	--	13.0	50.5	49.0	--	--

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	0	1	0	0	0	0	0	2												
Mn.#/Q	0	0.1	0	0	0	0	0	0.2												
Md.#/Q	0	0	0	0	0	0	0	0												
Mn.Size	--	1.2	--	--	--	--	--	1.0												
Md.Size	--	1.2	--	--	--	--	--	1.0												

Table 28. Size and abundance data for <u>Polydora</u> sp. (size = length of tube in mm)

	SET 1(9)				SET 2(9)				SET 3(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#					10	5	14	3	15	0	15	2
Mn.#/Q					1.1	0.6	1.6	0.3	1.7	0	1.7	0.2
Md.#/Q					1	0	1	0	1 **	0 ** *	1 *	0
Mn.Size					11.2	10.2	14.8	14.5	26.3	--	24.8	16.3
Md.Size					10.4	10.0	15.4	15.0	26.7	--	21.7	16.3

	SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	13	1	9	6	16	1	5	3	4	11	8	0
Mn.#/Q	1.4	0.1	1.0	0.7	1.8	0.1	0.5	0.3	0.4	1.2	0.9	0
Md.#/Q	1	0	1	1	1 *	0 *	0	0	0	1	0	0
Mn.Size	--	--	--	--	--	--	--	--	--	--	--	--
Md.Size	--	--	--	--	--	--	--	--	--	--	--	--

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#					6	7	9	11												
Mn.#/Q					0.7	0.8	1.0	1.2												
Md.#/Q					0	1	1	1												
Mn.Size					11.5	12.0	17.0	14.5												
Md.Size					11.7	9.2	18.3	15.0												

Table 29. Size and abundance data for serpulids too small to identify to genus (size = tube length in mm)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	8	5	8	8	4	9	8	10													0	1	0	0
Mn.#/Q	0.9	0.6	0.9	0.9	0.4	1.0	0.9	1.1													0	0.1	0	0
Md.#/Q	1	0	0	1	0	1	1	1													0	0	0	0
Mn.Size	6.3	6.2	9.8	13.0	13.8	20.2	26.8	43.1													--	4.2	--	--
Md.Size	5.8	5.8	10.4	14.2	14.6	18.3	23.7	39.6													--	4.2	--	--
					**			**																
						**		**																

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)				
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	
Total#																					
Mn.#/Q																					
Md.#/Q																					
Mn.Size																					
Md.Size																					

Table 30. Size and abundance data for Eupomatus gracilis (size = tube length in mm)

	SET 1(9)				SET 2(9)				SET 3(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#									4	5	5	6
Mn.#/Q									0.4	0.6	0.6	0.7
Md.#/Q									0	0	0	0
Mn.Size									42.5	61.6	61.6	70.3
Md.Size									40.5	66.7	71.7	65.0

	SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	5	7	4	9	4	7	5	9	5	6	6	5
Mn.#/Q	0.6	0.8	0.4	1.0	0.4	0.8	0.6	1.0	0.6	0.7	0.7	0.5
Md.#/Q	0	1	0	1	0	1	1	1	0	0	0	1
Mn.Size	101	97.5	40.6	81.5	74.1	81.1	102	82.5	114	113	126	81.9
Md.Size	100	100	102	81.3	73.3 *	83.3	102 *	80.0	108	110	135	97.6

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)				
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	
Total#																					
Mn.#/Q																					
Md.#/Q																					
Mn.Size																					
Md.Size																					

Table 31. Size and abundance data for _Spirobranchis spinosus_ (size = tube length in mm)

	SET 1(9)				SET 2(9)				SET 3(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#					0	0	1	0	0	1	1	0
Mn.#/Q					0	0	0.1	0	0	0.1	0.1	0
Md.#/Q					0	0	0	0	0	0	0	0
Mn.Size					--	--	3.3	--	--	14.2	10.8	--
Md.Size					--	--	3.3	--	--	14.2	10.8	--

	SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	0	0	2	0	0	1	0	0	1	0	1	1
Mn.#/Q	0	0	0.2	0	0	0.1	0	0	0.1	0	0.1	0.1
Md.#/Q	0	0	0	0	0	0	0	0	0	0	0	0
Mn.Size	--	--	58.6	--	--	59.3	--	--	90.0	--	76.6	103
Md.Size	--	--	58.6	--	--	59.3	--	--	90.0	--	76.6	103

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#																				
Mn.#/Q																				
Md.#/Q																				
Mn.Size																				
Md.Size																				

Table 32. Size and abundance data for _Serpula vermicularis_ (size = tube length in mm)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#									1	2	2	1	1	3	1	1	5	2	0	0	2	3	1	0
Mn.#/Q									0.1	0.2	0.2	0.1	0.1	0.3	0.1	0.1	0.5	0.2	0	0	0.2	0.3	0.1	0
Md.#/Q									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mn.Size									21.7	47.5	43.0	50.0	85.0	96.3	90.3	51.6	110	129	--	--	136	181	58.3	--
Md.Size									21.7	47.5	43.0	50.0	85.0	105	90.3	51.6	110	129	--	--	136	183	58.3	--

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#																				
Mn.#/Q																				
Md.#/Q																				
Mn.Size																				
Md.Size																				

Table 33. Abundance data for barnacle cyprid larvae shells

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	6	13	7	7	0	2	3	4	17	23	13	19	5	1	0	1	5	5	2	3	2	0	0	0
Mn.#/Q	0.7	1.4	0.8	0.8	0	0.2	0.3	0.4	1.9	2.6	1.4	2.1	0.6	0.1	0	0.1	0.6	0.6	0.2	0.3	0.2	0	0	0
Md.#/Q	1	1	1	1	0	0	0	0	2	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0
Mn.Size	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Md.Size	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	9	10	7	20	8	5	5	5	6	6	5	5	0	0	1	0	0	4	5	3
Mn.#/Q	1.0	1.1	0.8	2.2	0.9	0.6	0.6	0.6	1.2	1.2	1.0	1.0	0	0	0.2	0	0	0.8	1.0	0.6
Md.#/Q	1	1	1	2	1	0	0	1	1	1	1	1	0	0	0	0	0	1	1	0
Mn.Size	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Md.Size	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 34. Size and abundance data for balanoid barnacles too small to identify to genus (size = maximum diameter in mm)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	23	27	6	11	8	10	5	20	6	11	9	4	12	2	4	3	1	2	3	1	0	1	1	0
Mn.#/Q	2.6	3.0	0.7	1.2	0.9	1.1	0.6	2.2	0.7	1.2	1.0	0.4	1.3	0.2	0.4	0.3	0.1	0.2	0.3	0.1	0	0.1	0.1	0
Md.#/Q	2	3*	1*	1	1	1	1	2	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Mn.Size	0.7	0.7	0.6	0.7	0.8	0.8	0.8	0.8	1.0	0.8	1.0	1.2	0.9	0.8	0.7	0.8	0.8	2.3	1.2	1.3	--	1.0	0.8	--
Md.Size	0.7	0.6	0.6	0.7	0.8	0.8	0.7	0.8	1.0	0.8	1.0	1.2	0.8	0.8	0.7	0.8	0.8	2.3	1.2	1.3	--	1.0	0.8	--

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	8	8	5	3	6	1	6	1									0	1	1	1
Mn.#/Q	0.9	0.9	0.6	0.3	0.7	0.1	0.7	0.1									0	0.2	0.2	0.2
Md.#/Q	1	1	0	0	1	0	1	0									0	0	0	0
Mn.Size	1.0	0.9	1.0	0.8	1.0	0.8	0.8	0.8									--	0.7	0.7	0.8
Md.Size	1.0	1.0	0.9	0.8	1.0	0.8	0.9	0.8									--	0.7	0.7	0.8

Table 35. Size and abundance data for balanoid barnacles (size = maximum diameter in mm)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	24	28	7	11	8	10	5	21	8	19	11	6	16	4	5	8	5	4	4	3	2	1	2	1
Mn.#/Q	2.7	3.1	0.8	1.2	0.9	1.1	0.6	2.3	0.9	2.1	1.2	0.7	1.8	0.4	0.5	0.9	0.5	0.4	0.4	0.3	0.2	0.1	0.2	0.1
Md.#/Q	3	3 *	1 *	1	1	1	1	2	1	2	1	0	2	0	0	1	0	0	0	0	C	0	0	0
Mn.Size	0.7	0.7	0.6	0.7	0.8	0.8	0.8	0.9	2.5	1.3	1.2	1.1	2.2	4.2	5.0	2.2	4.2	3.1	1.5	2.9	5.8	1.0	6.0	9.5
Md.Size	0.7	0.6	0.6	0.7	0.8	0.8	0.7	0.8	1.5	1.3	1.3	1.0	1.2	1.0	1.3	1.2	3.8	2.3	1.2	3.8	5.8	1.0	6.0	9.5

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	8	8	5	3	7	2	7	1									0	1	1	1
Mn.#/Q	0.9	0.9	0.6	0.3	0.8	0.2	0.8	0.1									0	0.2	0.2	0.2
Md.#/Q	1	1	0	0	1	0	1	0									0	0	0	0
Mn.Size	1.0	0.9	1.0	0.8	1.1	0.8	0.9	0.8									--	0.7	0.7	0.8
Md.Size	1.0	1.0	0.9	0.8	1.0	0.8	0.8	0.8									--	0.7	0.7	0.8

Table 36. Size and abundance data for *Pollipes polymerus* (size = length in mm)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#									3	1	1	1	1	0	1	1	1	2	1	0				
Mn.#/Q									0.3	0.1	0.1	0.1	0.1	0	0.1	0.1	0.1	0.2	0.1	0				
Md.#/Q									0	0	0	0	0	0	0	0	0	0	0	0				
Mn.Size									0.5	0.3	0.5	0.3	0.7	--	0.5	0.7	0.5	0.5	0.5	--				
Md.Size									0.5	0.3	0.5	0.3	0.7	--	0.5	0.7	0.5	0.5	0.5	--				

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	0	2	0	2	6	7	12	7	3	2	1	1					0	1	0	0
Mn.#/Q	0	0.2	0	0.2	0.7	0.8	1.3	0.8	0.6	0.4	0.2	0.2					0	1.2	0	0
Md.#/Q	0	0	0	0	1	0	1	1	0	0	0	0					0	0	0	0
Mn.Size	--	0.5	--	0.5	0.5	0.5	0.5	0.5	0.7	1.0	0.5	0.5					--	0.5	--	--
Md.Size	--	0.5	--	0.5	0.5	0.5	0.5	0.6	0.7	1.0	0.5	0.5					--	0.5	--	--

Table 37. Abundance data for copepods

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(6)				SET 9(6)				SET 12(6)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	28	28	20	14	18	12	12	19	261	122	566	228	38	81	43	1	47	61	23	19	39	93	18	33
Mn.#/Q	3.1	3.1	2.2	1.6	2.0	1.3	1.3	2.1	29.0	13.6	62.8	32.0	6.3	13.5	7.2	0.2	7.8	10.2	3.8	3.2	6.5	15.5	3.0	5.5
Md.#/Q	3	2	2	2	2	1	1	2	27	12 **	65 **	22	4	13.5 *	6	0 *	8.5	10 *	3.5	3.5 *	7	14 *	3 *	4.5
Mn.Size	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Md.Size	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	123	70	83	115	87	70	144	249	175	245	107	422	100	38	264	62	48	133	91	6
Mn.#/Q	13.7	7.8	9.2	12.8	9.7	7.8	16.0	27.7	35.0	48.0	21.4	84.3	20.0	7.6	53.0	12.4	9.6	26.6	18.2	1.2
Md.#/Q	14 *	7 *	9	12	10 **	7 **	14	25 ** **	35	47	20 **	83 **	19	7	54	11	11	22 **	16	1 **
Mn.Size	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Md.Size	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 38. Size and abundance data for gammarids (size = length in mm)

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(9)				SET 9(9)				SET 12(9)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	0	3	2	1	3	2	3	5	14	14	14	3	1	0	8	0	2	5	14	0	25	72	81	16
Mn.#/Q	0	0.3	0.2	0.1	0.3	0.2	0.3	0.6	1.6	1.6	1.6	0.3	0.1	0	0.9	0	0.2	0.6	1.6	0	2.8	8.0	9.0	1.8
Md.#/Q	0	0	0	0	0	0	0	0	1 *	1 *	1 *	0 ***	0	0	1	0	0	0	1	0	3	8	9 *	2 *
Mn.Size	--	2.2	1.5	1.7	1.0	1.2	1.3	0.7	1.2	1.0	1.2	1.0	1.2	--	2.5	--	3.3	3.2	4.3	--	2.5	2.0	2.3	2.5
Md.Size	--	2.0	1.5	1.7	1.0	1.2	1.6	0.7	1.0	1.0	1.0	0.8	1.2	--	2.4	--	3.3	2.8	4.6	--	2.1	1.8	1.9	2.3

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	21	11	13	19	13	10	7	0	0	2	2	0	2	0	0	0	1	1	1	1
Mn.#/Q	2.6	1.2	1.4	4.3	1.4	1.1	0.7	0	0	0.4	0.4	0	0.4	0	0	0	0.2	0.2	0.2	0.2
Md.#/Q	3	1 *	1	4 *	2 *	1 *	0	0 **	0	0	0	0	0	0	0	0	0	0	0	0
Mn.Size	0.7	0.7	0.6	0.8	0.7	0.7	0.3	--	--	1.3	2.0	--	1.0	--	--	--	2.5	1.7	1.7	1.0
Md.Size	0.6	0.7	0.6	0.7	0.7	0.6	0.3	--	--	1.3	2.0	--	1.0	--	--	--	2.5	1.7	1.7	1.0

Table 39. Combined samples from the front and back of settling plates and adjacent wall (see text for explanation)*

Crepipatella lingulata (Size = maximum diameter in mm)

	SET 1(9)				SET 2(9)				SET 3(B)				SET 6(B)				SET 9(B)				SET 12(B)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#					1	1	0	0	4	6	2	8	34	31	59	12	28	22	26	28	61	70	67	43
Mn.Size					1.3	1.8	--	--	5.0	5.0	4.1	9.7	8.6	8.3	7.9	7.8	10.1	10.2	11.0	9.6	13.4	12.2	13.0	11.7
Md.Size					1.3	1.8	--	--	5.8	2.4	4.1	9.6	8.8	8.3	7.7	8.1	10.3	10.0	10.8	8.9	13.5	11.7	13.0	12.6
										*		*												

Hiatella arctica (Size = length in mm)

	SET 1(9)				SET 2(A)				SET 3(B)				SET 6(B)				SET 9(B)				SET 12(B)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	1	2	1	3	11	18	15	17	82	89	109	128	89	83	77	50	52	64	48	37	54	117	102	134
Mn.Size	1.2	1.4	2.5	2.5	3.9	3.4	4.8	6.0	9.8	10.3	10.7	10.7	6.1	7.1	7.8	7.0	3.1	4.2	2.8	3.2	6.2	5.2	5.2	5.1
Md.Size	1.2	1.4	2.5	2.7	4.0	3.5	4.5	6.1	10.4	10.1	10.9	11.0	5.1	7.0	4.8	5.4	3.2	3.9	2.2	2.1	5.5	4.6	4.5	4.4
						*		*										*		*				
																	*			*				

Hinnites multirugosus (Size = hinge line length in mm)

	SET 1(9)				SET 2(9)				SET 3(B)				SET 6(B)				SET 9(B)				SET 12(B)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#									10	5	8	11	3	6	5	1	2	1	0	0	2	3	2	0
Mn.Size									4.3	4.5	4.8	5.3	20.5	20.8	18.3	8.8	28.0	6.7	--	--	46.0	12.2	15.3	--
Md.Size									3.3	4.2	3.7	4.5	20.4	20.8	18.8	8.8	28.0	6.7	--	--	46.0	14.5	15.3	--
														*		*								

* (9) = front; (A) = front + back; (B) = front + back + wall

Table 39. continued

Kellia laperousii (Size = maximum diameter in mm)

	SET 1(9)				SET 2(A)				SET 3(B)				SET 6(B)				SET 9(B)				SET 12(B)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	5	8	4	1	15	11	34	34	108	74	153	165	20	34	2	10	11	3	0	2	14	46	46	24
Mn.Size	1.5	1.3	2.8	3.7	3.7	2.7	4.4	3.8	6.5	6.2	6.2	6.5	6.6	6.8	6.2	7.8	5.0	3.4	--	2.6	5.8	5.2	4.3	4.5
Md.Size	1.0	1.3	2.9	3.7	3.7	3.1	2.9	3.6	7.0	6.8	6.7	7.1	6.9	6.8	7.0	8.5	6.8	3.3	--	2.6	6.5	6.1	5.6	4.2
																					*		*	

Leptopecten latiauratus (Size = hinge line length in mm)

	SET 1(9)				SET 2(A)				SET 3(B)				SET 6(B)				SET 9(B)				SET 12(B)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	0	0	2	1	0	0	2	2	7	9	22	5	10	11	4	2	0	2	1	0	1	0	3	0
Mn.Size	--	--	0.8	0.8	--	--	0.8	3.8	12.7	16.7	14.9	16.7	14.0	13.0	13.3	11.4	--	10.2	12.7	--	2.0	--	9.3	--
Md.Size	--	--	0.8	0.8	--	--	0.8	3.8	14.0	16.2	15.2	17.5	12.3	10.7	10.8	11.4	--	10.2	12.7	--	2.0	--	7.8	--

Mytilus edulis (Size = length in mm)

	SET 1(9)				SET 2(9)				SET 3(B)				SET 6(B)				SET 9(B)				SET 12(B)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total#	6	5	13	6	17	27	12	25	155	222	224	229	171	189	187	217	79	63	73	71	69	80	57	100
Mn.Size	0.8	0.8	1.0	1.2	1.5	1.4	1.4	2.3	8.0	8.9	8.8	10.3	23.2	25.2	22.0	20.3	36.0	36.9	35.8	35.9	45.2	41.8	44.2	41.4
Md.Size	0.8	0.8	1.0	1.2	1.3	1.3	1.6	2.0	8.5	7.5	9.0	10.0	26.0	27.7	25.5	22.2	37.8	39.1	37.7	36.4	47.3	45.8	47.6	43.0
	**			**		*		*	**			**		**	**								*	*
		*		*						**		**		**		**								
											*	*												
									*	*			*			*								

Table 40. Combined samples from the front and back of Set 6, 9 and 12 settling plates

Chama pellucida (Size = maximum diameter in mm)

	SET 6				SET 9				SET 12			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total #	9	6	7	11	16	8	15	13	5	9	12	7
Mn. Size	1.9	1.8	1.6	2.7	4.4	3.1	5.1	3.3	7.3	7.4	6.8	7.3
Md. Size	1.8	1.7	1.3	1.3	4.4	2.6	3.5	3.0	7.2	7.5	5.3	7.0

Ostrea lurida (Size = maximum diameter in mm)

	SET 6				SET 9				SET 12			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total #	33	23	51	16	39	23	52	14	19	8	34	12
Mn. Size	6.4	4.6	9.8	6.2	15.4	11.2	19.2	10.6	31.5	15.9	26.6	34.3
Md. Size	5.8	4.2	9.2	5.1	14.0	10.0	17.1	7.75	33.8	10.8	23.7	42.8
		**	** *	*		**	** *	*	*	** *	*	** *

Pododesmus cepio (Size = maximum diameter in mm)

	SET 6				SET 9				SET 12			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total #	8	7	2	1	7	7	0	1	7	4	0	0
Mn. Size	26.9	29.0	18.2	4.3	34.0	38.8	--	13.0	50.8	47.8	--	--
Md. Size	30.0	29.8	18.2	4.3	34.0	36.7	--	13.0	50.8	50.2	--	--

Table 40. continued

<u>Eupomatus gracilis</u> (Size = length in mm)

	SET 6				SET 9				SET 12			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total #	7	7	12	11	5	9	5	10	6	7	8	8
Mn. Size	89.0	97.5	90.0	80.2	74.4	80.1	101	79.2	111	108	119	86.5
Md. Size	93.4	100	92.5	80.0	75.0	83.4	102	78.3	104	108	132	98.2
					*	*	***	*				

<u>Serpula vermicularis</u> (Size = length in mm)

	SET 6				SET 9				SET 12			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total #	1	3	3	2	8	3	1	0	3	3	1	1
Mn. Size	85.0	96.0	77.3	63.3	106	133	63.3	--	136	180	583	550
Md. Size	85.0	105	90.2	51.7	110	135	63.3	--	137	183	583	550
						*	*					

<u>Spirobranchis spinosus</u> (Size = length in mm)

	SET 6				SET 9				SET 12			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total #	1	0	2	0	0	1	0	0	1	0	2	1
Mn. Size	40.0	--	58.7	--	--	59.3	--	--	90.0	--	75.0	104
Md. Size	40.0	--	58.7	--	--	59.3	--	--	90.0	--	75.0	104

Table 41. Species diversity data

	SET 1(9)				SET 2(9)				SET 3(9)				SET 6(6)				SET 9(6)				SET 12(6)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total # of Species	16	17	19	17	18	21	23	20	36	37	37	37	39	36	35	33	36	30	32	32	31	27	33	23
Mn. # of Species/Q	8.4	9.4	9.5	8.2	7.9	8.4	8.9	9.1	17.7	18.0	18.4	17.5	23.5	21.0	19.5	18.0	18.7	19.0	18.0	17.0	16.2	19.5	17.3	15.2
Md. # of Species/Q	7	9	9	8	8	9	9	9	19	17	18	17	24 *	20.5	19.5	18 *	18	18.5	17.5	17.5	16	19.5 *	17	14.5 *
Mn. Shannon Index/Q	1.91	2.06	1.90	1.82	1.56	1.77	1.70	1.79	2.41	2.54	2.17	2.44	2.18	2.24	1.67	1.58	2.17	2.29	2.18	2.04	2.40	2.52	2.29	2.27
Md. Shannon Index/Q	1.88	2.02	1.82	1.69	1.70	1.74	1.75	1.76	2.41	2.55 **	2.21 **	2.52	2.21	2.40 *	1.71	1.61 *	2.14	2.30	2.20	2.06	2.44	2.52 *	2.37	2.27 *

	SET 1b(9)				SET 1c(9)				SET 1d(5)				SET 1e(5)				SET 3b(5)			
	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH	A1	A2	HA	HH
Total # of Species	14	13	12	15	23	22	19	27	21	18	17	17	13	10	15	12	24	25	25	24
Mn. # of Species/Q	6.8	6.7	5.9	7.4	9.2	11.7	9.0	11.4	13.4	12.0	12.2	11.2	8.8	6.4	9.4	6.0	16.2	15.8	15.6	14.6
Md. # of Species/Q	6	6	6	8	9 *	12 * *	9 *	12	14	12	12	11	9	7	10 *	6 *	16	16	15	15
Mn. Shannon Index/Q	1.33	1.57	1.29	1.20	1.97	2.02	1.56	1.53	1.75	1.72	1.50	1.00	1.51	1.36	1.53	1.16	1.75	1.92	1.49	1.43
Md. Shannon Index/Q	1.36	1.59 **	1.23	1.16 **	2.00 ** *	2.08 ** **	1.53 ** *	1.58 ** **	1.75 **	1.74 **	1.49	0.99 ** **	1.54	1.41	1.61 *	1.20 *	1.77	1.90 ** *	1.46 *	1.53 **